Aquatic Enhancement
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Lake Diagnostic Study
Wall Lake
Lagrange County, Indiana

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For the:

Wall Lake Fisherman's Association

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Executive Summary

Statement of Project Purpose

This study was undertaken with joint funding provided by The Wall Lake Fisherman's Association, Inc. and the Indiana Department of Natural Resources Division of Fish and Wildlife.

Project goals were the following:
•Collect and compile information on the current and historical chemical, physical, and biological characteristics of Wall Lake and its watershed.
•Use the above information to look for trends in water quality and the causes of recent water-quality problems at Wall Lake including algal blooms and excessive plant growth.
•Explore the biological, social, and recreational implications of past, present, and future watershed land-use and water-quality at Wall Lake.
• Recommend a set of possible steps toward protecting and improving water-quality, aquatic biological integrity, and recreational-use at Wall Lake.

Wall Lake is a 141 acre natural kettle (glacial) lake located in the northeast corner of Lagrange County Indiana. The lake lies approximately two miles south of the Michigan border and approximately one mile west of the town of Orland. Wall Lake's shoreline is mostly developed with approximately 161 lakeside homes and cottages. There is an Indiana Department of Natural Resources public access site located on the lake's south side. The total surface area of the lake is approximately 57 hectares (141 acres). Wall Lake is comprised of two somewhat separate basins of 105 and 36 acres separated by a narrow peninsula. The maximum depth of the lake is 10.36 meters (34 feet) and the mean depth is 3.5 meters (11.6 feet).

The Wall Lake Fisherman's Association, Inc., a non-profit lake association, serves to tie the lake residents together for the purposes of maintaining and managing the lake and surrounding community. The association owns and operates a clubhouse near the lake to serve as a gathering place for lake residents and a forum for discussing organizational business and lake management activities. The association has been active in helping to manage the lake, addressing problems with aquatic plants and initiating this study through a combination of private and Lake and River Enhancement (LARE) grant funding. The most popular activity on Wall Lake by both resident and non-resident users is fishing, with boating, swimming, and enjoying the natural beauty and wildlife at the lake also popular.

Wall Lake has experienced some lingering problems with fish growth rates and size. The lake has been surveyed three times by Indiana Department of Natural Resources fisheries biologists. A 1969 fish survey noted low growth rates on Bluegills, Redear sunfish, Perch, and Largemouth Bass. The survey report recommended a fish eradication and restocking to improve the fishery, but this was never carried out. In a 1987 survey fish growth rates still lagged but the percent of catchable sized fish had increased. No major management activities were recommended in 1987. Wall Lake was surveyed again in 2003 and once again showed lagging panfish and largemouth bass growth rates, and a low percentage of catchable sized fish. A problem with overpopulation by bluegills was apparent. The report concluded that the Wall Lake fish population was only capable of providing marginal sport fishing opportunities. To improve the sport fishery the biologists recommended that the Division of Fish and Wildlife establish a walleye population in Wall Lake to attempt to reduce the panfish population through predation and provide for fishing opportunities for that species. It was also suggested that this program would involve chemically treating the lake from the shoreline to the five foot contour with a piscicide (fish toxicant) to selectively remove part of the panfish population. This would be coupled with the annual stocking of advanced (six to eight inch) walleye fingerlings at a rate of ten to fifteen per acre. This would be accompanied by an 18 inch minimum walleye size limit and daily bag limit of two. Due to a lack of project funding these recommendations were not carried out. In the fall of 2005 the Wall Lake Fisherman's Association with the direction of IDNR fisheries biologists funded and carried out a private stocking of walleye in Wall Lake as recommended.

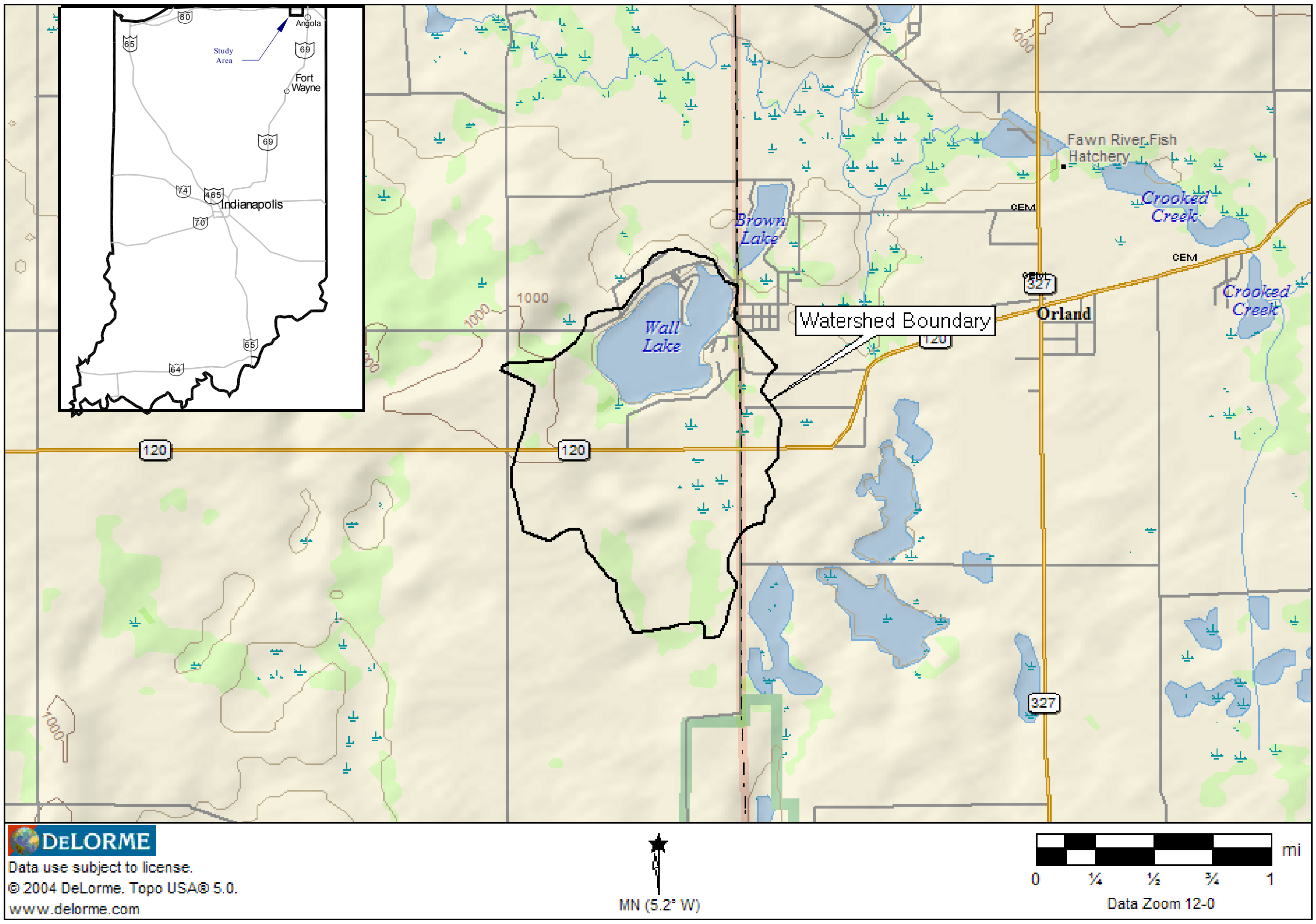
Wall Lake has a relatively diverse aquatic plant community with eleven species of native plants. Since 1996 Eurasian watermilfoil, an invasive non-native aquatic plant has become a problem at Wall Lake. The plant has colonized over 20 acres of Wall Lake and has interfered with boating and the aesthetic quality of the lake. Curlyleaf pondweed, another exotic plant has also been noted growing in the lake, although it has been less of a problem than the milfoil. The Wall Lake residents have hired a professional applicator to treat the milfoil for several seasons but growth returns each season. In 2004 the Wall Lake Fisherman's Association, Inc. developed a plant management plan for the lake utilizing a cost-share grant from the IDNR Lake and River Enhancement Program (LARE). In 2005 further cost share funding was provided by the LARE program to initiate a spring 2005 whole-lake type herbicide treatment as recommended by the plan. Significant Eurasian watermilfoil persisted through midsummer of 2005 but control of the plants was complete by fall. Data on the lake's plant community is collected and analyzed periodically to monitor success. Milfoil growth is expected to be minimal in 2006 due to the effectiveness the of the 2005 treatment. The Wall Lake residents have applied for funding to continue the current plant management plan in 2006 including an early-season treatment for Curly-leaf pondweed, plant community monitoring, and treatment of any returning Eurasian watermilfoil growth. Purple loosestrife, a non-native invasive wetland plant has begun to colonize the lakeshore at Wall Lake. If left uncontrolled and allowed to spread this plant will likely enter the watersheds wetlands where it can potentially damage the ecology of the wetlands and their function as a positive influence on water quality.

Wall Lake has experienced occasional algae blooms in recent years, but compared with other Indiana lakes Wall has historically displayed good water quality, with good water clarity, and low nutrient levels. Water clarity was also very good in August when sampling was performed for this work, with a Secchi disk measurement of 13.1 feet. Levels of phosphorus, the nutrient that most profoundly affects water clarity and quality, were below lab detection limits in 2005. Wall Lake water quality has been sampled during four previous seasons since 1973. An examination of the water quality over time, including sampling in 2005 does not show a profound decline in water quality or major nutrient enrichment over that time period. It does appear that organic nitrogen levels and lower strata (lake bottom) phosphorus levels have increased overall since sampling began in 1973. Use of mathematical modeling to estimate sources of phosphorus to Wall Lake indicate that lakeside septic systems provide the bulk of phosphorus contribution (39%). Dissolved phosphorus in runoff from agricultural areas of the Wall Lake watershed is estimated to also be a significant contributor (33%).

Wall Lake's 753 acre Watershed is roughly ovate, extending 1.5 miles south of the lake. The primary land use is agricultural (54%) with significant woodlands (11%) wetlands (9%) and developed areas (8%) also draining to the lake. Two small tributaries feed Wall Lake on the lake's south side. These were dry for most of the 2005 season due to droughty conditions. Baseline tributary flow sampling on 8/17/05 showed the West Tributary to be significantly higher in phosphorus and much lower in dissolved oxygen than the East Tributary. Wetland floodings in the east tributary drainway may help oxygenate flow-through waters and remove nutrients from this tributary. Flow rates were relatively low on both tributaries so phosphorus loading to the lake in the 2005 season from these tributaries was minimal. E-coli levels were high on both tributaries. Contaminant levels were probably worse than in normal seasons due to a lack of flushing of these areas earlier in the season. Based on information collected for this report the following goals for management of Wall Lake and its watershed are recommended:

1. Work with Watershed Property Owners to Seek Long Term Legal Protection of Watershed Wetlands and Woodlands.
2. Initiate a control program for Purple Loosestrife to prevent the spread of this invasive plant to the watershed's wetlands
3. Continue Direct Fish Management Activities to Enhance the Wall Lake Fishery. Asses the effectiveness of the 2005 walleye stocking and maintain the walleye population if effective.
4. Seek the Connection of Lakeside Residences to a Centralized Sewage Collection System.
5. Continue to Pursue the Goals Established in the Wall Lake Aquatic Vegetation Management Plan with assistance from the Lake and River Enhancement Program.
6. Work with Watershed Property Owners to Seek the Enhancement of Habitat in the Watershed's Wetlands.
7. Work With Area Landowners, County Soil and Water Conservation Staff, and the USDA Natural Resources Conservation Service to maximize the application of Best Management Practices on Agricultural Lands in the Watershed.

Because the Wall Lake Fisherman's Association is very motivated to maintain and improve the lake's recreational viability and ecological integrity, prospects are good for making significant improvements in the lake and watershed utilizing the above recommendations. The association should follow up on these recommendations working with the IDNR, The USDA Natural Resources Conservation Service, county soil and water conservation districts and local landowners. Continued educational efforts through the association newsletter and functions along with attending area lake management conferences and workshops can help generate interest and promote awareness in preserving and maintaining the health of the lake far into the future.



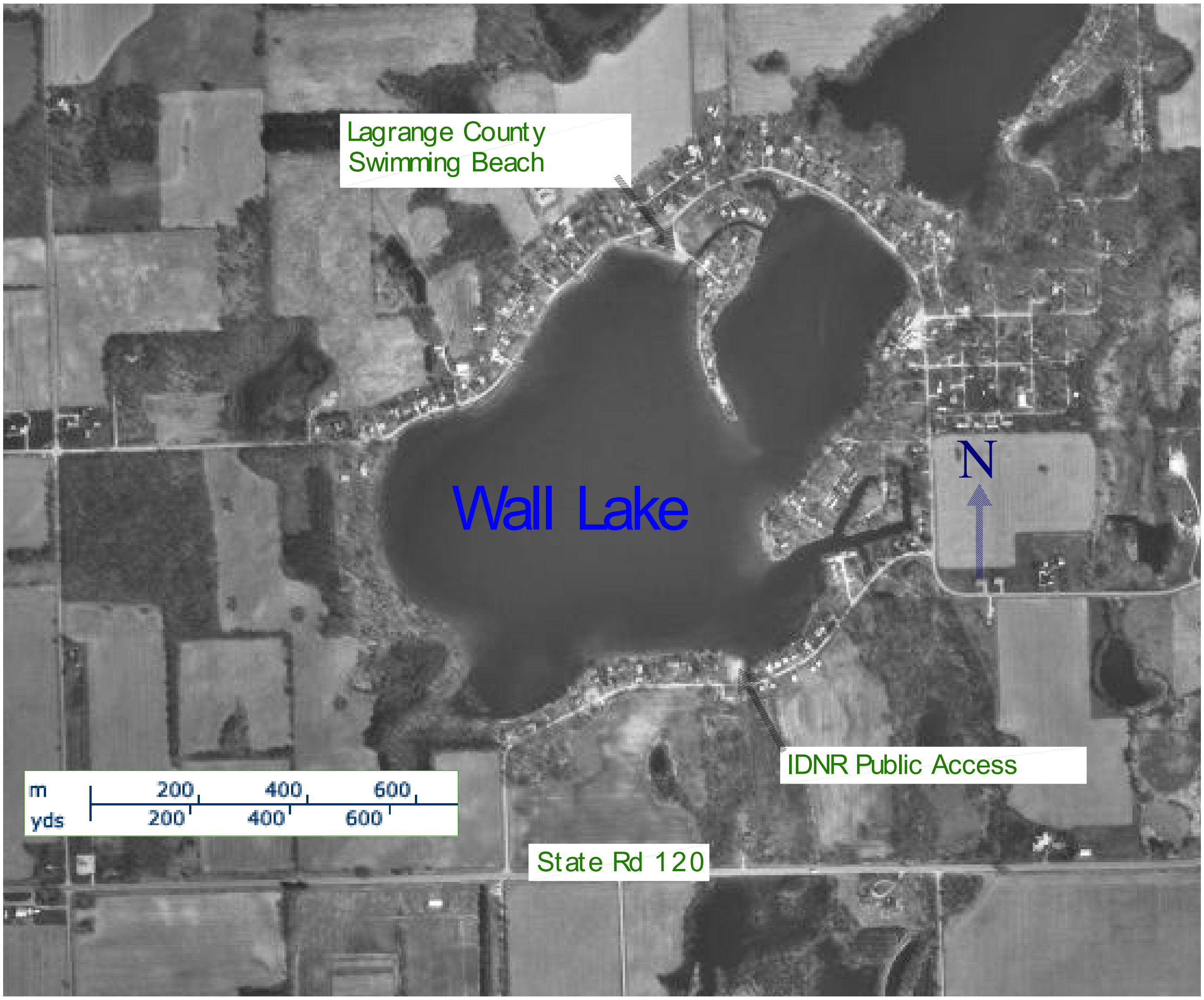
Map 1-1 Wall Lake project area location

1. Introduction to Wall Lake and Its watershed

Wall Lake is a 141 acre natural lake located in the extreme northeast corner of Lagrange County in Northeast Indiana. The lake lies approximately two miles south of the Michigan border within sections 24 and 25 of Greenfield Township. The town of Orland Indiana lies approximately one mile east of Wall Lake. (see map 1-1 above) Wall Lake's shoreline is mostly developed with approximately 161 lakeside homes and cottages. The lake is divided by a narrow peninsula into a large southwest basin and a smaller northeastern basin. There is an Indiana Department of Natural Resources public access site located on the lake's south side. A concrete boat ramp and gravel parking lot allows for public launching of boats at this site. Lagrange County also maintains a public swimming beach on the lake's north side. Uses of the lake include fishing, swimming, and boating up to a speed limit of 10 miles per hour. Wall Lake's 753 acre Watershed is roughly ovate, extending 1.5 miles south of the lake. The primary land use is agricultural with significant wetlands and developed areas also draining to the lake.

1.1 Historical Perspective

Like most northeastern Indiana lakes Wall is a Glacial Kettle Lake formed by large glaciers present in Northern Indiana during the late Pleistocene era, approximately ten thousand years ago. Kettle Lakes like Wall Lake generally were formed by large blocks of glacial ice which broke free of the main glacier and were left on the landscape or buried in outwash deposits for a period after the recession of the main glacial edge. As these ice blocks melted they filled their respective depressions in the soil with their melt-water, leaving northeastern Indiana



Map 1.1-1 USGS Satellite Photo of Wall Lake

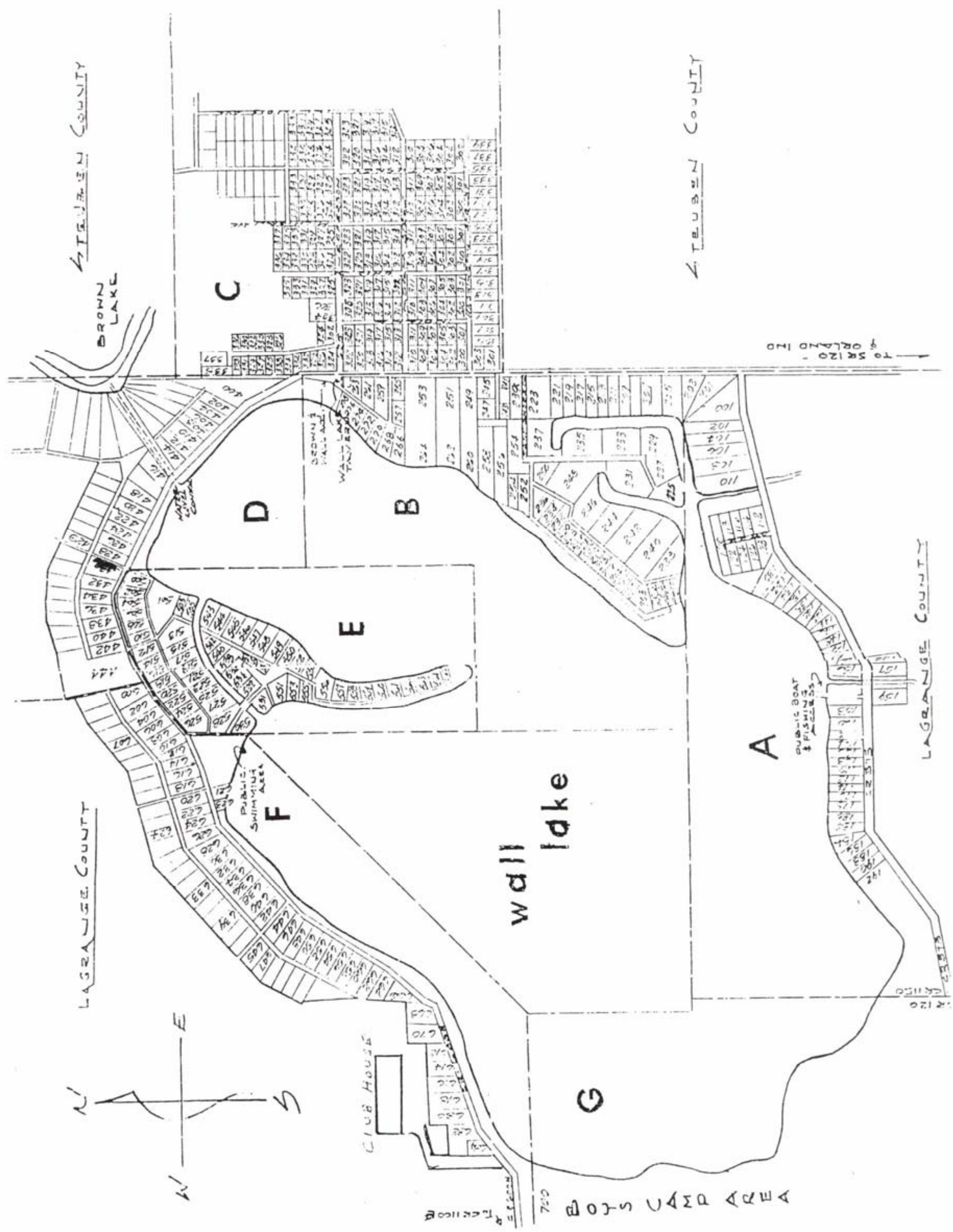
dotted with natural lakes and marshes. The eastern edge of Wall Lake's 753 acre watershed lies within Steuben County Indiana while the remainder lies within Lagrange County. Maps and records obtained from the Indiana State Archive indicate that the Wall Lake area was first surveyed in 1834. The surveyor's notes of land and timber indicate that the gently rolling lands in the Wall Lake watershed at that time were primarily oak barrens (savanna photo 1.1-1), wet prairie, and woodland. Many areas may have been maintained in an open herbaceous (non-woody) plant assemblage through the influence of periodic natural fires or fires started by native peoples present in presettlement times. The area probably served as a hunting grounds for the Potawatomi

Photo 1.1-1 Oak Barren (savanna) like those originally present in The Wall watershed, photo courtesy of Saint John's Arboretum

Indians who sometimes used burns as a hunting and game habitat management technique. Tree species present included White Oak, Black Oak, Hickory, Elm, Ash, Sycamore, Willow, Sassafras, and Beech. The largest of the surveyor's bearing trees tended to be oaks, one of which was 40 inches in diameter, with 36 inch trees being common. Due to land-use changes and modern fire suppression most Wall Lake watershed areas not currently in agricultural or residential use now contain forest or woody shrubs. Wall Lake drains through a culvert to Brown Lake to the Northeast. Brown Lake drains to the Fawn River about two miles north of Wall Lake. The Fawn River west of the Wall Lake area runs roughly due West meandering back and forth across the Michigan-Indiana state line, eventually joining with the St. Joseph River (tributary to Lake Michigan) at Constantine Michigan.

Just four years after initial surveying in 1834 the Vermont Settlement was established at present day Orland one mile East of Wall Lake and the conversion of area lands to agriculture began. The 1893 plat book for Lagrange County shows the Wall Lake shoreline almost wholly in the possession of two principle landowners, Rachel C. Fair and G.W. Neihardt. Conversion of the vast majority of watershed lands to agricultural use had probably been complete by that time. Attempts at draining watershed wetlands south of the lake had already begun with the establishment of Graves Ditch through a natural drainway ending on the south shore of the lake, shown as a small tributary stream on the original survey map. This same ditch/stream enters the lake today near the public access. Ditching constructed to facilitate drainage of another wetland system Southeast of the lake had been completed at some time prior to 1938.

A 1938 aerial photograph shows 13 summer cottages were built close to the lake (Lagrange Health 1975). Agricultural lands were extended right to the edge of the lake along the lake's south shore at that time. Two sections of shoreline in the southwest portion of the lake remained wooded with one bordered by a riparian emergent/scrub shrub wetland still present today. Present day County Road East 600 North provided access to the lake along the north shore. By 1957 most of the Wall Lake shoreline contained homes and cottages with the exception of the west and southwest shoreline. The west shoreline contained a Boy's Camp, the remnants of which are still present in the ownership of the grandson of the original property owner. By 1957 a 2.5 acre channel system was also under construction in the Southeast portion of the lake and two channels had been constructed off of the northeastern basin of the lake. Spoils had likely been used to fill riparian wetlands in these areas and homes had been built. By 1965 home building on the constructed channels in the southeast portion of the lake had begun. Other areas of the Wall Lake Shoreline had been developed to the extent of the present day at that time. The lakeside has been platted in five subdivisions with an approximate total of 200 numbered riparian parcels (see map 1.1-2). Many parcels have been purchased and built upon with multiple lots per dwelling, giving the lake its current number of approximately 161 homes and cottages. The Wall Lake Fisherman's Association Inc. serves as the lake resident's advocate organization and social meeting place. For a small lake Wall Lake has a very active association. A 30 by 40 foot association clubhouse was established through donations and dedicated to the Association in 1981. (Anderson 2004) The association carries out a regular summer schedule of events and fundraisers and has been active in helping to manage the lake through a combination of private and public grant funding.



Map 1.1-2 Platting around Wall Lake

Surface area sq feet	6142733.26
Surface area sq meters	570678.59
area acres	141.02
area hectares	57.07
mean depth ft	11.60
mean depth meters	3.54
maximum depth ft	34.00
maximum depth meters	10.36
relative depth %	1.22
volume ac-ft	1635.81
volume cu-ft	71255705.86
volume gallons	534417793.97
maximum length ft	3894.19
maximum length meters	1186.95
maximum width ft	2445.96
maximum width meters	745.53
mean width ft	1577.41
mean width meters	480.79
shoreline length ft	18366.76
shoreline length meters	5598.19
shoreline development	2.09

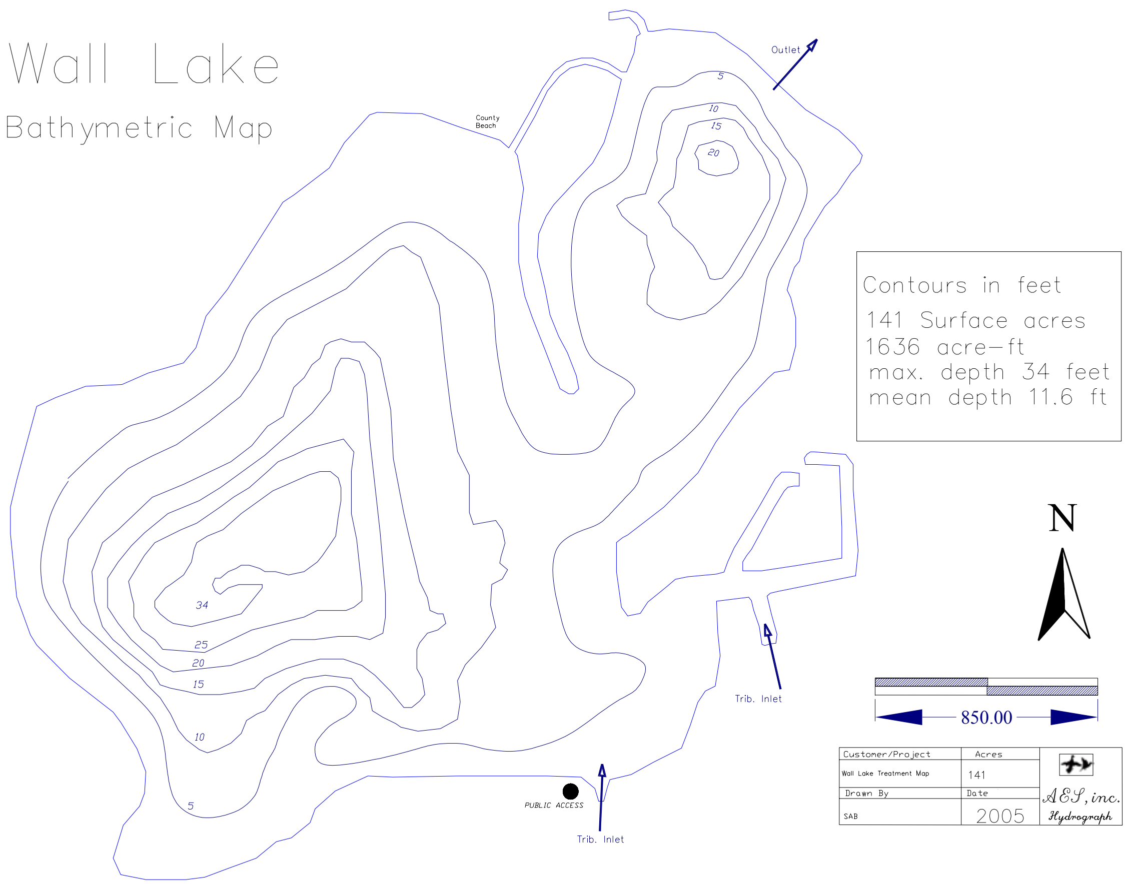
Table 2.1-1 Wall Lake Morphometric Parameters

2. Lake Characteristics

2.1 Morphometry

Wall Lake is divided into two distinct basins of approximately 105 and 36 acres. (see map 2.1-1) The total surface area of the lake is approximately 57 hectares (141 acres). These basins are separated by a narrow peninsula. Both basins are characterized by a deeper, relatively flat central area with a steep step up onto shallower surrounding sand or gravel bottomed flats. The maximum depth of the larger southwestern basin is 10.36 meters (34 feet). The smaller northeastern basin has a maximum depth of 6.1 meters (20 feet). The lake has a mean depth of 3.5 meters (11.6 feet).

The *relative depth* of a lake is the ratio of the maximum depth as a percentage of the mean diameter of the lake at the surface, expressed as a percentage. Most lakes have a relative depth of less than two percent. Very deep lakes with a small surface area usually have a relative depth of over four percent. Wall Lake being a relatively shallow lake has a relative depth of 1.2 percent. Wall Lake contains approximately 1636 acre-feet of water or approximately 534 million gallons of water. The *maximum length* of Wall Lake (farthest distance that wind can act upon the surface of the water without interference from land) is 1187 meters (3894 feet). Wall's *maximum width* (perpendicular to the maximum length) is 746 meters (2446 feet). The length of Wall Lake's shoreline is approximately 5598 meters (18367 feet). Wall's *Shoreline Development* (ratio of shoreline length to the shoreline length of a perfectly circular lake of equal size) is 2.09. With the shoreline development of a perfectly circular lake being 1, this is an indication of Wall Lake having a moderate potential for biological productivity due to a relatively long length of interface between the terrestrial and aquatic habitats for the size of the lake. Wall Lake's shoreline development is increased considerably by the presence of the channels and the peninsula extending into the lake from the north shore.



Map 2.1-1 Wall Lake Bathymetry

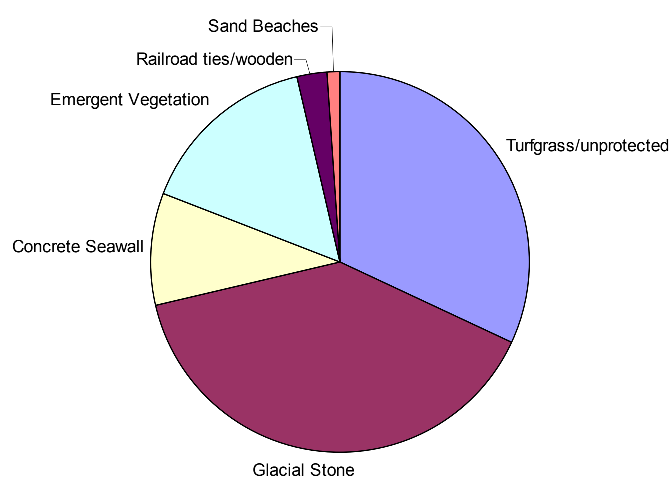
2.2 Shorelines

A lake's shorelines can be important with respect to the biological integrity of the lake and the lakes water quality. Stones, gravel, woody structure, and wetland vegetation all provide habitat for certain types of juvenile and adult fish and benthic macroinvertebrates. Riparian wetlands and emergent shoreline vegetation can provide a natural buffering or filtering effect for lake-bound runoff. Stones, woody structure, and wetland vegetation can help buffer wind driven or boat-caused wave energy and stabilize shoreline soils prone to erosion. A survey of Wall Lake's shoreline types was performed by traversing the shoreline in a boat and on foot on the ice carrying a WAAS enabled hand-held GPS unit. Waypoints were recorded at each significant change in shoreline types and then converted to computer aided drawing coordinates and placed on the map of Wall Lake. (See map 2.2-1 pg. 20) The shorelines of Wall Lake were classified according to the following types:

Shoreline Type	**Description**
Turfgrass/unprotected	Lawn to the waters edge at the time of the survey, few or no added stones, rip rap or other structures to armor the shoreline
Glacial Stone	A significant amount of added natural rounded stones or stone/concrete rip rap present to armor the shoreline against erosion
Concrete Seawall	Poured or placed flat concrete structure at or near the waterline at the time of the survey
Emergent Vegetation	A significant amount of native emergent plants present on, along or just lake ward of the shoreline
Railroad Ties/wooden	Stacked or driven railroad ties, landscape timbers or wooden seawall
Sand Beaches	Relatively Level sandy substrate present at and just above the waterline lacking significant indication of erosion

Table 2.2-1 Descriptions of Shoreline Classifications Used in the Wall Lake Survey

Wall Lake Shoreline Type Distribution



Graph 2.2-1 Wall Lake Shoreline Types

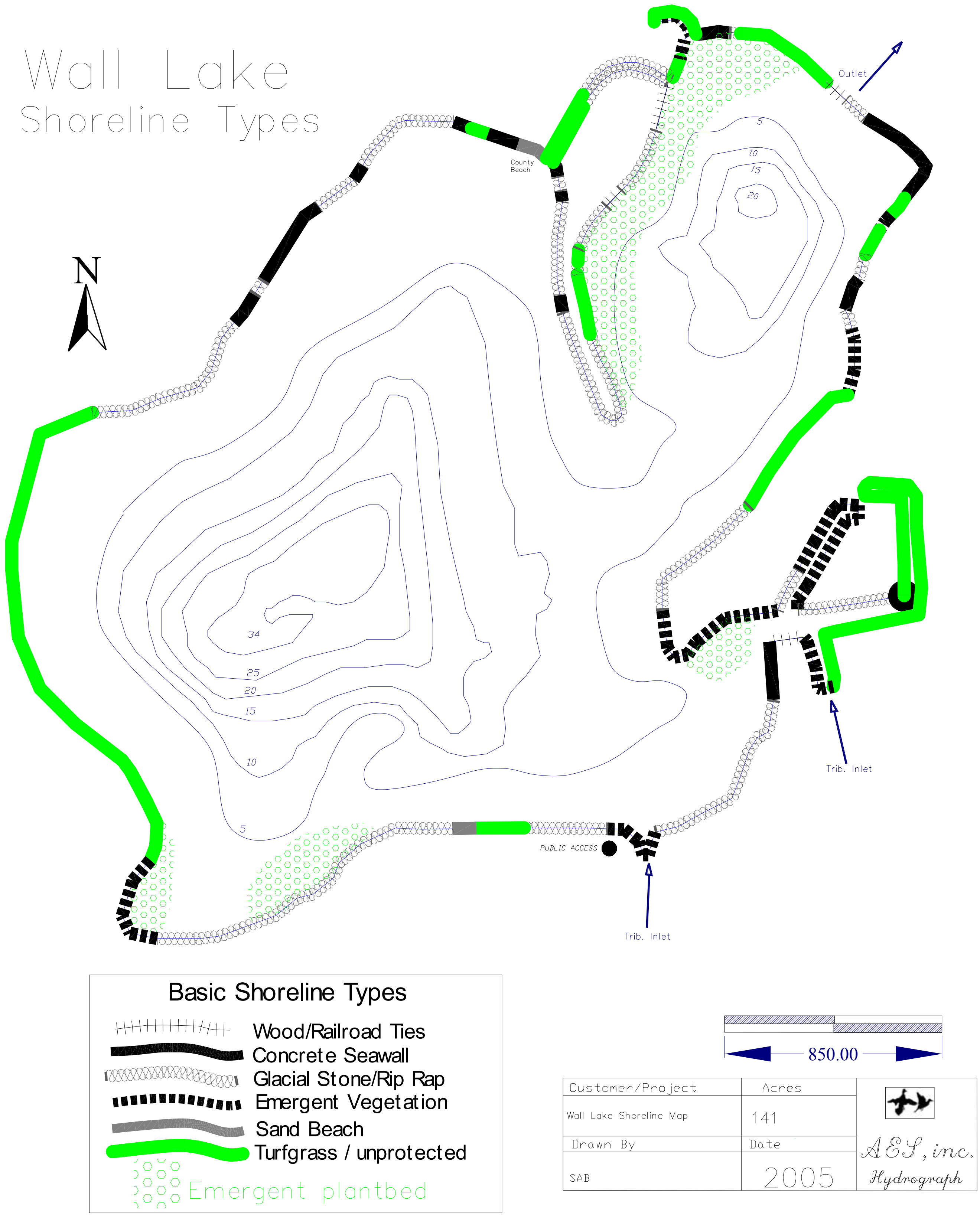
Wall Lake Shoreline Types (ft)	% of total shoreline
Turfgrass/unprotected	Turfgrass/unprotected
6449	32%
Glacial Stone	Glacial Stone
7937	39%
Concrete Seawall	Concrete Seawall
1868	9%
Emergent Vegetation	Emergent Vegetation
3122	16%
Railroad ties/wooden	Railroad ties/wooden
515	3%
Sand Beaches	Sand Beaches
221	1%
Approx. Total shoreline	Approx. Total shoreline
20112	100%

Table 2.2-2 Wall Lake Shoreline Types

Approximately 20112 feet of shoreline was measured and mapped in the survey. (see map 2.2-1) A 1938 set of aerial photos indicates that Wall Lake may have originally had significant stretches of natural sand beaches and emergent vegetation. Today 16 percent of the shoreline still contains significant amounts of emergent vegetation, even in areas where the shorelines have been developed or armored with glacial stone. These shoreline plants are a positive asset with respect to water quality at Wall Lake and should be encouraged where possible. Sand beaches currently account for only about 221 feet of shore line (approx. 1%). The dominant shoreline type on Wall Lake is Glacial Stone that has been placed by the residents to help prevent shoreline erosion. Approximately 7937 feet (39%) of the Wall Lake shoreline contains significant amounts of glacial stone. In areas susceptible to erosion by wave action glacial stone is the preferred method of artificial shoreline armoring. The complex habitat offered by the stones is more beneficial to fish and wildlife than most other forms of shoreline armoring and the many angles of refraction presented by the stones help dissipate energy from waves striking the shore rather than reflecting wave energy back lakeward like concrete seawalls. Approximately 6449 feet (32%) of the Wall Lake shoreline consists of unprotected turf grass. Some of these areas also contain some amount of emergent vegetation or an uncut strip of grasses along the lakes edge. Both are assets from a water quality standpoint and should be encouraged.

As an added benefit Canada geese that cause problems for residents at the lake can be deterred by the uncut strips of vegetation along the shoreline. In some situations this acts to provide a barrier to accessing lawns for grazing. Problems with goose droppings in yards along Wall Lake are common with geese often staying at the lake year-round. Even during ice cover in January fifty Canada Geese were noted to be using the lake.

Shoreline erosion was relatively minor across all shoreline types on Wall Lake with the exception of some steep banked crumbling areas in the manmade channels. The lack of erosion is probably attributable to the lake's 10 mile per hour speed limit which prevents the generation of large boat wakes. Enforcing this speed limit, encouraging the planting and growth of emergent vegetation, and encouraging the establishment of tall vegetated shoreline buffer strips along Wall Lake's edge will help to prevent the development of shoreline erosion in the future. In areas requiring shoreline armoring the use of glacial stone should be encourage over concrete, wooden, or steel seawalls. Emergent vegetation plantings can also be used in combination with glacial stone to provide further buffering of wave energy.



Map 2.2-1 Distribution of Wall Lake Shoreline Types

2.3 The Wall Lake Fishery

In a resident survey performed as part of this work Wall Lakers ranked fishing as the lake related activity they enjoy most often. In fact, fishing was ranked as being over twice as popular as the second ranking activity (swimming).

Lake Activity	Number of Lake Residents Indicating This as Favored Activity
Fishing	30
Swimming	12
Boating/Cruising	11
Other/Aesthetics	5
Kayaking/Canoeing	2
Sailing	0

Table 2.3-1 Wall Lake Residents Rankings of Favored Lake Activity

Angling at Wall Lake is also important to users who launch boats at the public access. As part of this study the Wall Lake residents recorded launches and landings at the public access during the course of one day and the purpose for each. Between 7:30 a.m. and 4:00 p.m. on Friday August 26th six boats were launched. All were visiting the lake for the purpose of fishing. Lake residents also report that local bass clubs hold outings on Wall Lake each season. A mailed survey card sent to Wall Lake residents as part of this study solicited votes from residents on which fish species they sought most often. Bluegills and redear sunfish taken as a single category were by far the most popular fish sought registering twice the votes of the next most popular fish. Bass ranked second with black crappie coming in third.

Fish Species	Number of Residents Indicating This Species Sought Most Often
Bluegill/Redear Sunfish	41
Largemouth/Smallmouth Bass	20
Black Crappie	13
Perch	9
Do Not Fish	8
Northern Pike	3
Other (Walleye)	1
Channel Catfish	0

Table 2.3-2 Wall Lake Residents Rankings of Fish Species Sought most often

Because Wall is a public freshwater lake the fishery is monitored by the Indiana Department of Natural Resources Division of Fish and Wildlife. Wall Lake is within Fisheries Management District II headquartered at Fawn River State Hatchery located two miles north of Orland on State Road 327. Wall Lake as a fishery resource has received ample attention from IDNR fisheries biologists. In 1957 the lake was hydrographically surveyed by IDNR. In 1969 an IDNR fisheries survey was performed. This was followed by additional surveys in 1987 and again in 2003. In IDNR fisheries surveys, district fisheries personnel use a variety of methods to collect fish from the lake, weigh, count, and measure collected fish, and remove a sample of scales from fish within given size categories. After this, collected fish are released live when possible. The fish scales collected are later closely examined in the lab to determine fish age. Knowing fish weight, length, and age allows conclusions to be drawn about fish growth rates within the surveyed lake. The table below contains the species collection information from the Wall Lake fish surveys:

Species	1969	1987	2003
Bluegill	493	709	547
Hybrid sunfish	0	49	0
Yellow perch	128	69	13
Rock bass	0	0	3
Yellow bullhead	52	49	13
Warmouth	9	47	15
Spotted gar	0	0	7
Largemouth bass	29	67	98
Brown bullhead	29	74	38
Redear sunfish	58	420	248
Pumpkinseed	9	28	2
Bowfin	8	3	1
Golden shiner	8	13	0
Grass pickerel	0	14	2
Northern pike	6	2	9
Black crappie	0	26	17
Green sunfish	0	2	9
Lake chubsucker	57	7	0
Common carp	1	0	0
Brook silverside			Present
Bluntnose minnow	0	0	2
Total	**887**	**1579**	**1024**
Sampling Effort			
Night Electrofishing hrs	2 A.C.	1 D.C.	1 D.C.*
Gill net lifts	8	6	6
Trap net lifts	4	3	3

Table 2.3-2a Fish Collection data for Wall Lake, 1969, 1987, 2003. Adapted From IDNR Fish Management Report 2003

* Note: In 2003, all fish were collected during the first 30 minutes of electrofishing. Largemouth bass were collected during the entire 60 minutes of sampling.

In the 1969 survey biologists used a combination of seining, trap netting, gill netting and D.C. electrofishing to collect fish from Wall Lake. The report summary was as follows: During this survey 912 fish representing 16 species were collected. The dominant species collected by number were bluegill (54%), yellow perch (14%) and redear (6.4%). Growth rates and weights were below average. Largemouth bass only represented 3.2% of the sample by number. Based on below average growth rates and weights, low numbers of harvestable size fish and weak or missing largemouth bass year classes, it was recommended that the Wall Lake fish population be totally eradicated and the lake restocked. This recommendation wasn't acceptable to some lake residents who sought a Lagrange County temporary injunction and restraining court order. This court order was filed September 25, 1970 but later dismissed June 2, 1971. The fish eradication and restocking project was never conducted. (IDNR 1969,2003) Five problems among four fish species were specifically noted in the 1969 Survey Report:

1. Below average rate of growth on bluegill and redear
2. Below average condition factors on bluegill, redear, and yellow perch
3. Poor length frequency distribution in bluegill, yellow perch and largemouth bass
4. A low percentage of catchable size fish with bluegill, yellow perch, and largemouth bass
5. A Small predator population (largemouth bass)

In Wall Lake's second IDNR fish population survey in 1987 fish sampling methods included gill netting, trap netting, and nightime D.C. electrofishing. The fishery report summary was as follows: During this survey, 1634 fish representing 17 species were collected. The dominant species collected numerically were bluegill (43.4%), redear (25.7%), brown bullhead (4.5%), yellow perch (4.2%) and largemouth bass (4.1%). The dominant species by weight were spotted gar (34%), redear (17.5%), bluegill (12%), and largemouth bass (10.4%). Bluegill and redear represented 69% of the fish population. Although growth rates and weights for bluegill, redear and bass remained below average for Northeast Indiana lakes, the percent of harvestable size fish had increased. Management options to improve the Wall Lake fish population were limited and management beyond the survey could not be justified. (IDNR 1987, 2003)

At the suggestion of IDNR the Wall Lake Fisherman's Association attempted to help improve the fishery by constructing two brush pile fish attractors in February of 1994. Several clumps of Christmas trees were placed on the ice over 16 to 20 feet of water on the southwest side of the lake. The DNR supervised the placement and assisted Wall Lake residents with the work.

In 2003 INDR surveyed Wall Lake again. The report summary of fish collected reads as follows: During the 2003 survey 1024 fish representing 17 species were collected. The dominant species numerically were bluegill (53.4%), redear (24.2%) and largemouth bass (9.6%).. Combined, these three species represented over 87% of the sample by number and 57% by weight. The major species collected by weight were largemouth bass (21.4%), redear (18.9%), bluegill (17.4%) and northern pike (14.9%). A total of 547 bluegill were collected weighing 33.26 pounds. Four-hundred and fifty-seven of these bluegill were collected during the first 30 minutes of electrofishing. Bluegill dominated the sample by number (53.4%) and represented 17.4% of the sample by weight. They ranged in length from 1.4 inch (age I+) to 7.9 inches (age VIII). Growth rates were well below average. Three and four year old bluegill were 1.7 and 2.1 inches smaller than the mean for northeast Indiana lakes. Only 20%

of the bluegill were harvestable size (6 inches or larger). It was noted that the domination of the Wall Lake fish population by slow growing bluegill and redear seen in the previous surveys had continued. Growth rates on these fish were well below average and the percentage of harvestable fish had also declined. Largemouth bass growth rates that had been average in 1987 had declined and now fell below average despite the abundant panfish forage population present. The report concluded that the Wall Lake fish population was only capable of providing marginal sport fishing opportunities. A plant survey performed as part of the work in 2003 also noted that the growth of Eurasian watermilfoil, an invasive non-native aquatic plant, had become significant enough to warrant aggressive treatment.

To improve the sport fishery the report also recommended that the Division of Fish and Wildlife establish a walleye population in Wall Lake to attempt to reduce the panfish population through predation and provide for a fishing opportunity for that species. It was also suggested that this program would involve chemically treating the lake from the shoreline to the five foot contour with a piscicide (fish toxicant) to selectively remove part of the panfish population. This would be coupled with the annual stocking of advanced (six to eight inch) walleye fingerlings at a rate of ten to fifteen per acre. It was also suggested that an 18 inch minimum walleye size limit and daily bag limit of two should be implemented. Due to lack of project funding these recommendations were not carried out. In the fall of 2005 the Wall Lake Fisherman's Association with the direction of IDNR fisheries biologists funded and carried out a private stocking of walleye in Wall Lake as recommended.

Wall Lake has demonstrated the problem with panfish growth rates through the years, compounded by lagging survival and growth of largemouth bass. (See tables 2.6, 2.7, 2.8) Low growth rates are common problems with fish populations in lakes, especially with bluegills. In most cases this occurs as bluegill spawning and recruitment outpaces predation, increasing bluegill numbers and thus decreasing the amount of available forage per fish. This often occurs when the influence of predator fish such as largemouth bass is reduced due to removal by fisherman or poor year class survival. Once this condition occurs in a lake it can be difficult to remedy short of a complete eradication and restocking. Evidence suggests that walleye can be significant predators on bluegills, even during the winter when other predatory species such as largemouth bass are less active. (Schneider and Breck 1997) Protecting and assessing the walleye population established in Wall Lake and continuing with the stocking program with guidance provided by IDNR will be a recommendation of this report. Whereas fishing is by far the most popular lake activity, maintaining and fostering a good fishery should be among the highest priorities for the association. With bluegill being the most popular species sought addressing problems with fish growth to the extent possible will be wise. Continuing the current control program for Eurasian watermilfoil to prevent the establishment of dense plant habitat that can hinder panfish predation by larger fish will also be a recommendation. Protecting the lake from water quality declines that can also complicate the problem will be an important step as well. The Wall Lake fisherman's Association may also wish to consider carrying out the recommended selective removal of panfish from Wall Lake under permitting from IDNR. Despite the evidence of slow panfish growth rates some lake residents report satisfaction with the size and number of bluegill caught so ultimately the association will need to asses the costs and benefits associated with this management technique. If funding becomes available for IDNR to perform the selective eradication most larger panfish will not be affected by the treatment. The potential for a major negative effect on catchable sized bluegill is minimal.

BLUEGILL									
Survey Year	Percent Harvestable	Average Back Calculated Length (inches) at Each Age							
		I	II	III	IV	V	VI	VII	VIII
1969	7.5	1.4	2.3	3.1	4.9	5.8			
1987	30	1.5	2.4	3.3	4.2	5.3	6.0		
2003	20	1.4	2.1	3.0	4.0	5.0	5.9	6.5	6.9
District Average		1.7	3.1	4.7	6.1	6.9	7.4		

Table 2.3-3 Percent Harvestable Bluegill and back calculated Lengths per age class from IDNR survey Data

REDEAR SUNFISH									
Survey Year	Percent Harvestable	Average Back Calculated Length (inches) at Each Age							
		I	II	III	IV	V	VI	VII	VIII
1969	23			3.2	4.5	5.4	6.3		
1987	70	1.7	2.8	4.2	5.1	6.2	6.9		
2003	53	1.4	2.4	3.5	4.6	5.6	6.3	7.1	7.9
District Average		2.2	3.4	4.7	6.2	7.4	6.8		

Table 2.3-4 Percent Harvestable Redear and back calculated Lengths per age class from IDNR survey Data

LARGEMOUTH BASS

Survey Year	Percent Harvestable	Average Back Calculated Length (inches) at Each Age							
		I	II	III	IV	V	VI	VII	VIII
1969	10			6.5	9.0				
1987	20	2.5	5.6	8.6	11.7	13.5	15		
2003	3	3.1	5.4	7.6	9.6	11.4			
District Average		3.5	6.9	9.5	11.6	13.4	14.7		

Table 2.3-5 Percent Harvestable Largemouth Bass and back calculated Lengths per age class from IDNR survey Data

2.4 Aquatic plants in Wall Lake

Wall Lake tends to exhibit good water clarity and contains a diverse variety of aquatic plants. Assessment of aquatic plants at Wall Lake began with a cursory species inventory performed as part of the early IDNR fishery surveys. The 1969 survey (INDR 1969) noted that the biologists identified nine species of submersed aquatic plant and eight species of emergent plants. It was also noted that none of the aquatic vegetation was considered a problem as growth was scattered and limited in abundance. The two dominant species were Sago pondweed *Stuckenia pectinata* and Bushy pondweed (probably *Najas flexilis*). Sparse plant growth was noted to a depth of eight feet. By 1996 the presence of dense colonies of Eurasian watermilfoil, an invasive non-native plant, had become noticeable on Wall Lake but were limited primarily to the southwest corner of the large lake basin and the western edge of the smaller basin (see figure 2.4-1).

Background on Eurasian Watermilfoil:

Wall lake like many Indiana lakes has been colonized by the aquatic plant, Eurasian Watermilfoil *Myriophyllum spicatum* . A native plant of Europe, Asia, and north Africa Eurasian milfoil in the U.S. was first documented growing in a pond in Washington D.C. in 1942. The plant was probably intentionally introduced to the United States (Couch and Nelson 1985) and has now spread to forty-five of the lower forty-eight states and the Canadian provinces of British Columbia, Ontario, and Quebec. At least 160 glacial lakes in Northern Indiana now contain the plant (IDNR 1997). Eurasian watermilfoil is capable of spreading and reproducing by fragmentation. This has hastened its invasion by allowing introduction to occur from plant fragments attached to boat trailers. Spread can also occur from plant fragments which enter a lake from upstream in flowing tributaries. Once established, most localized reproduction occurs by stolon (root) formation with more distant colonization occurring through fragmentation (Aiken et al 1979, Madsen et al 1988). Under experimental conditions it has been demonstrated that up to 46% of fragments that settle on aquatic substrate become established (Madsen etal 1997). Obviously fragments produced by powerboat traffic can increase the rate of spread. Eurasian watermilfoil can be an extremely invasive and fast growing aquatic plant given proper conditions. It often tends to gain a strong foothold colonizing areas of ecological disturbance such as dredged shoreline areas, regions of excessive sedimentation, and nutrient enriched lakes. Eurasian watermilfoil can be an extremely destructive inhabitant in some lakes because of its invasive nature. Displacement of more beneficial native species often takes place as the fast growing milfoil achieves a dense canopy over native plant beds, depriving the slower growing species of sunlight. The resulting loss of diversity and increase in habitat complexity can cause a variety of trophic changes in an overgrown aquatic system including reduced predatory success and growth of piscivorous gamefish (Strange et al 1975) and reduced growth of panfish (Crowder and Cooper 1982). In shallow lakes milfoil biomass can become extensive enough to cause winter or summer fishkills as plant material decomposes during periods of low light in late summer or extensive snow and ice cover in winter. Milfoil infestations commonly cause problems for boaters, swimmers, and fisherman as dense growths of the plant reach the surface and grow laterally forming unsightly vegetative mats. Many thousands of dollars per year are spent in Indiana on control programs, with extensive treatments taking place locally on Crooked Lake (Steuben) and Hamilton Lake. Lake responses to milfoil infestation vary greatly. In some lakes Eurasian milfoil shows limited growth, competing side by side with native plants as an integrated member of the floral community, causing problems only in limited areas. In other cases the plant quickly displaces native plant communities becoming a major nuisance within the first five years of colonization. In Wall lake Eurasian milfoil has followed a pattern of colonization that is common. Stands of the plant have grown primarily between a depth of six and twelve feet following this contour more or less in a ring around the lake's basins. While invading milfoil has largely displaced native plantbeds within the six to twelve foot contour, native pondweeds have maintained dominant growth in many shallower areas. The acreage of milfoil at Wall Lake continues to increase slightly each year with more occurrence in shallow water apparent in recent seasons.

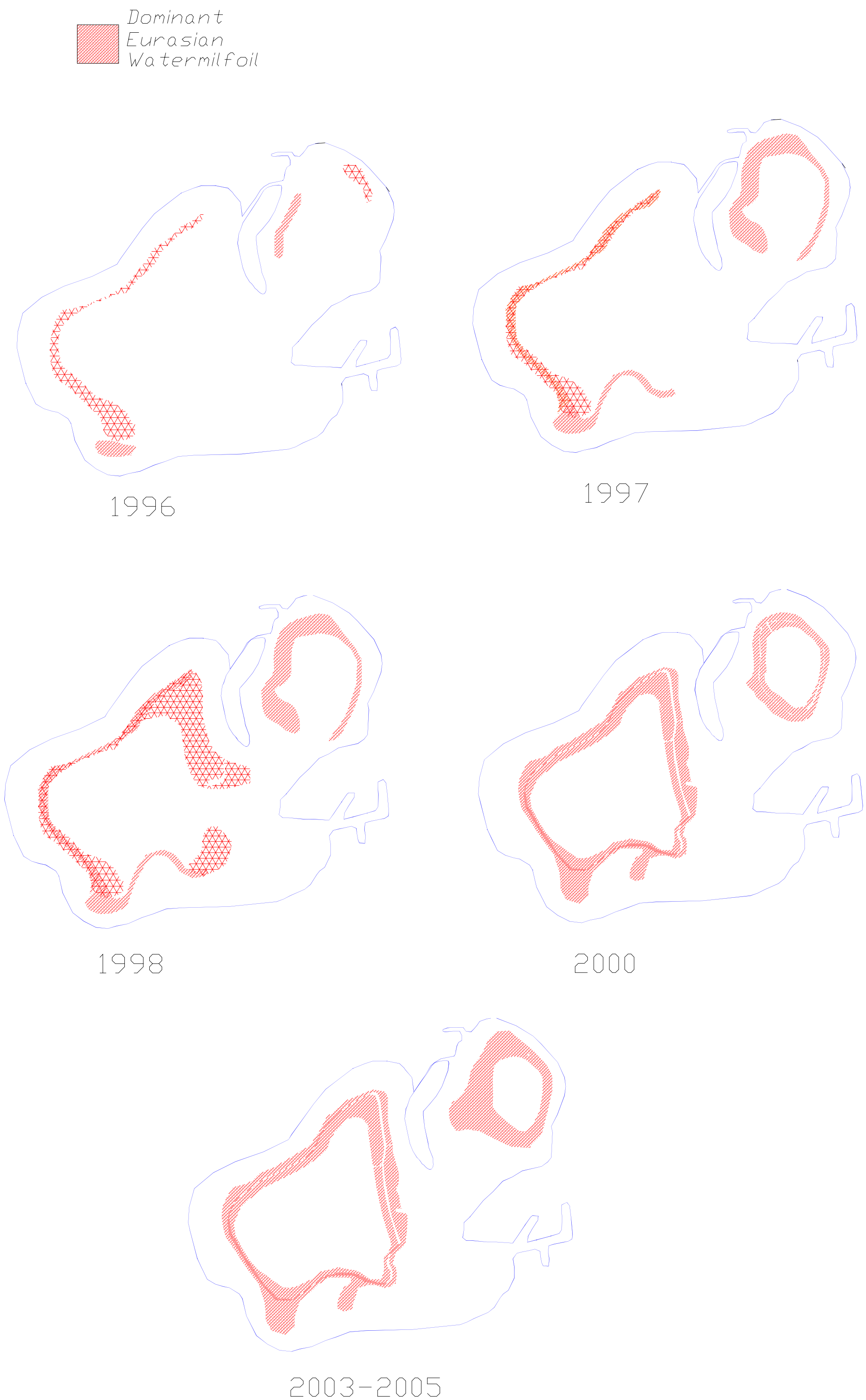
In the 1996 season Aquatic Enhancement & Survey, Inc. began seasonal mapping of the lake's plantbeds through a combination of visual inspection and rake tosses in preparation for a control program in the open lake (shorelines and offshore areas of the main lake basins) and also control of milfoil and native plants in all the lake's channels. By 1998 residents on the channels had contracted for control of aquatic vegetation in the channels via aquatic pesticide application. Residents had also begun to note an increasing interference in fishing and boating from dense milfoil growth in the open lake and the Wall Lake Fisherman's Association hired Aquatic Enhancement & Survey, Inc. to treat approximately 14 acres of Eurasian watermilfoil in the lake's two basins. 2-4-D granular aquatic herbicide was applied at the rate of 100 pounds per surface acre and the milfoil was very effectively controlled. In 1999 milfoil growth returned and increased to approximately 20 acres. The open lake was not retreated that season but treatment continued on the channels. In 2000 2-4-D granular herbicide was once again applied to approximately 22 acres of milfoil in the open lake and the channels were treated with contact herbicides. Results were very good with live milfoil plants being very difficult to find one month after the treatment. In 2001 approximately the same acreage of milfoil was noted and it was decided that since the 2-4-D treatments had not decreased the acreage of milfoil returning the following season Reward® aquatic contact herbicide (diquat dibromide) would be

Photo 2.4-1 Dense Milfoil Colonies are Visible on the Surface of Wall Lake in Recent Seasons

used at a slightly lower cost. The contact herbicide produced excellent results similar to prior season's control using 2-4-D. In 2002 the Wall Lake fisherman's association opted to try mechanical harvesting as a means of control. Due to poor results the harvesting was discontinued in favor of treatment with diquat dibromide contact herbicide treatment in 2003. Contact herbicide use was repeated on approximately the same acreage on the lake and channels with excellent results on Eurasian watermilfoil that season.

For the 2003 season IDNR fish survey random plant sampling was also performed to better document Wall Lake's plant community. Random rake tosses were used to collect plant community data and produce a number of statistical plant community descriptors. These techniques have been outlined by IDNR in two documents (IDNR 2004), (Pearson 2004). In this survey rake tosses were performed at 60 random sampling sites within the littoral zone (plant growing area) of Wall Lake. 13 species of submersed aquatic plants were noted in the survey. Aquatic plants were present at 58 of the 60 littoral zone sampling sites. Chara, a type of bottom growing algae was the most abundant plant sampled at 67 percent of sites. Illinois pondweed *Potamogeton illinoiensis* was second most abundant being present at 38 percent of sampling sites. Eel grass, *Vallisneria americana* was third most abundant, sampled at 37 percent of sites. Eurasian watermilfoil was found at 27 percent of sites. Because the survey was performed after the milfoil treatment in the 2003 season Eurasian watermilfoil was probably substantially reduced. Sago pondweed was not found in the survey and was probably also reduced post-treatment as it is somewhat susceptible to the contact herbicide treatment performed. A native milfoil, Northern watermilfoil was also noted in the survey. The Wall Lake plant community was deemed to be relatively diverse with several beneficial plant species present. Eurasian

Figure 2.4-1 Approximate extent of Eurasian Milfoil Colonization on Wall Lake 1996-2003


Dominant
Eurasian
Watermilfoil
1996
1997
1998
2000
2003-2005

watermilfoil was noted to be increasing, especially in waters eight to 15 feet deep. It was suggested that the milfoil problem may not have reached a level that would warrant a whole lake chemical treatment, but was abundant enough to justify an aggressive control program. The report further advised that the association hire a consultant to develop a long range aquatic plant management plan to address Eurasian watermilfoil citing funding newly available through the IDNR Lake and River Enhancement Program (LARE) for that purpose.

Later in the 2003 season the Wall Lake fisherman's association applied for the funding to develop an aquatic plant management plant through the Indiana Department of Natural Resources Lake and River Enhancement Program. This would allow a more detailed analysis of the lake's plant community and possibly allow more complete long term control of the Eurasian watermilfoil problem through the use of a whole-lake treatment not financially feasible without assistance. In addition to the milfoil causing navigation problems by fouling boat motors it was feared that the milfoil would damage the existing native plant community by out competing several beneficial species such as Eelgrass *Valisneria americana* and Illinois pondweed *Potamogeton Illinoensis*. Plants such a Illinois pondweed tend to grow in a less crowded open

Photo 2.4-2 Illinois pondweed, a beneficial aquatic plant

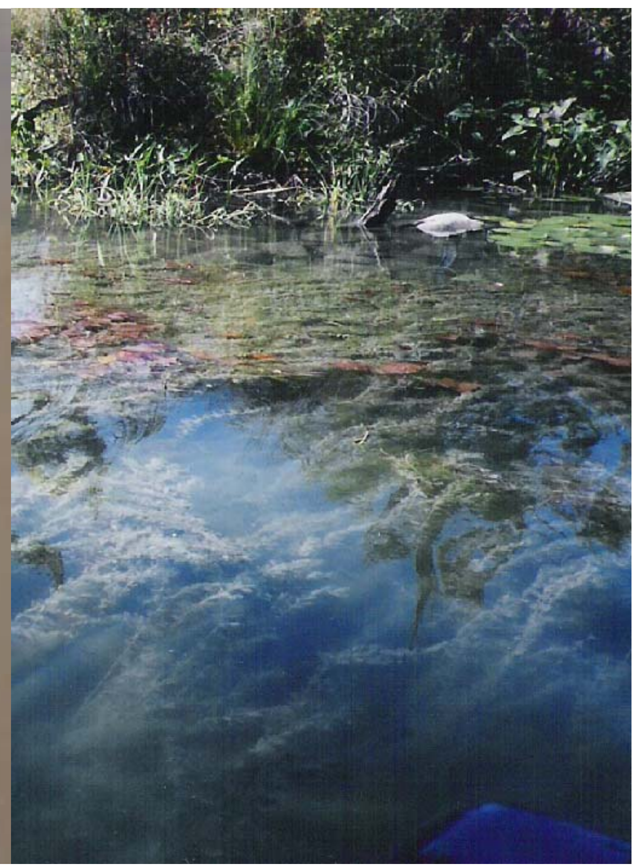


Photo 2.4-3 Mat-forming Eurasian watermilfoil

architecture configuration that provides beneficial habitat enhancement without providing a serious hindrance to boat traffic and other lake activities. By contrast Eurasian watermilfoil is often a dense-growing and mat-forming plant, excluding the passage of boat motors and creating a complex habitat where predatory fish have less ability to control panfish populations. (see photos 2.4-2, 2.4-3) In Wall Lake where bluegill already appear to be too numerous and growth of predatory bass lags, allowing a milfoil infestation to worsen would not be wise. Even when the milfoil is well controlled by treating seasonally with systemic or contact herbicides to relieve ecological and navigational problems, a temporary loss of water clarity results as a side effect as decomposition of the dead plants occurs. With the exception of Sago pondweed, native plants had been largely excluded from areas heavily colonized by Eurasian milfoil. Curly-leaf pondweed *Potamogeton crispus* another non-native invasive species, although not at problem-growth levels, also appeared to have become somewhat more prevalent, especially between the eight to 12 foot depth contours and also had the potential to develop into a problem. The association was successful in securing funding and the plan was developed in 2004.

Photo 2.4-4 Graduated Sampling Rake Used in Tier I and Tier II aquatic plant surveys

The plan development included plant surveys in accordance with IDNR Tier I and Tier II plant survey protocols (IDNR 2004) and the use of the collected data to produce plant maps.

Description of Tier I sampling method

To assemble data for the plant management plan report a Tier I reconnaissance survey (IDNR 2004) was performed in the summer of 2004. In this qualitative survey a boat was used to cruise the lake's littoral zone in a zigzag pattern, making rake tosses and using visual observation to divide the lake's littoral zone into numbered plant bed units based on like plant species, composition and density. Information collected at each plant bed includes species,

species number, substrate, depth, and bed location. A numeric score of one to four is assigned for each species as a measure of abundance within the bed. For plant beds with a plant canopy, a canopy score of one through four is assigned. Canopy abundance scores are recorded as they apply to submersed, non-rooted floating, rooted floating, and emergent vegetation.

Description of Tier II sampling method

Additionally, Tier II random sampling was utilized in the summer of 2004 to establish random plant sampling points and quantify approximate species biomass at each respective point. In tier two sampling, a toss of a two-sided rake on a rope is used to sample vegetation from the lake bottom at each point. After retrieval of the rake a score is assigned to each recovered plant species by separating the species and placing them back on the rake. Thickness of the plants when placed back on the rake is recorded as measured by 5 equally spaced marks on the rake tines. (see photo 2.4-4) This measurement assigns a rake score of one to five to each species as a basic measure of biomass. Plants seen but not recovered on the rake are marked as "observed only". Filamentous algae is recorded only as "present" if recovered on the rake. Location data for plantbeds and sampling points was collected using a WAAS enabled GPS unit. Data points were then converted to grid coordinates and mapped using computer aided drafting software. AutoCAD® software was used to calculate plantbed and treatment area acreages.

As Part of the plant management plan (Aquatic Enhancement 2005) three major goals for Wall Lake's plant community were established:

1. Restore and maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality and is resistant to minor habitat disturbances and invasive species.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public recreational access to Wall Lake while minimizing the negative impacts on plant, fish and wildlife resources.

The 2004 season plant surveys on Wall Lake showed good diversity with fourteen species of native submersed aquatic plant and three exotic species found. A species diversity index (SDI) of .86 was calculated for Wall Lake's 2004 season plant data, showing good diversity in comparison to a mean SDI of .66 from a set of 21 sampled Northern Indiana Lakes (Pearson 2004). Chara was most commonly found, being sampled at 39 of 60 sites. Sampling sites with Eurasian watermilfoil were most commonly found between the six and twelve foot depth contour. Milfoil biomass was very low due to treatment earlier in the season. Slender naiad, Illinois pondweed, and Vallisneria were also common showing a strong remaining native plant community and good restoration potential. The plant plan recommended addressing watershed nutrient inputs through this diagnostic study and established a five-year plan for control of Eurasian watermilfoil. The plan provided the following summary of options for controlling the plant problems:

•Insect Biological Control:
A North American Weevil, *Euhrychiopsis lecontie*, may be associated with natural declines in Eurasian milfoil at northern lakes (Sheldon 1994, Bratager et al. 1996, Weinberg 1995). In recent years the weevils have been marketed and stocked as a biological control agent with varying results. Historically associated with the native milfoils, the insects are capable of grazing on Eurasian milfoil as well, while not affecting the majority of native vegetation. A control program involves breeding the weevils in captivity, collecting them and then physically attaching the insects to the target plants in the field. The stocked weevils sometimes produce a modest reduction in milfoil biomass among targeted plants during the first season. In most cases restocking must occur every year to maintain control, in many cases no reduction in plants is noted at all after stocking. Interest in the use of the milfoil weevils has been high. They are often viewed as a natural control method that will be less environmentally damaging than more effective forms of control. At present, the high cost and relatively low reductions in plant biomass associated with weevil stocking programs has severely limited their popularity as a control mechanism.

•Harvesting:
There are several models of machines produced for cutting and removal of aquatic vegetation from lakes. Contractors who own the machines generally hire on to cut plants on an hourly basis with organizations that can provide a set minimum hours of work to cover mobilization costs. Most harvesters are constructed like a floating combine. The floating machine is driven and steered with paddle wheels. An underwater cutting bar cuts plant stems and a driven belt carries the cuttings to the back of the machine where they are deposited in a hopper. When the machines hopper is full the machine operator offloads the aquatic cuttings in a designated area or into the back of a truck for disposal. One advantage of harvesting is the actual removal of plant material and associated nutrients from the lake. Unfortunately, only a very small percentage of a lakes nutrient load is invested in plant biomass at any given time. In most cases the cutting will have to be repeated each season and often multiple cuttings per season are needed to control plant regrowth. A major disadvantage of harvesters is the amount of biological disturbance introduced to the lake during the cutting process. Eurasian watermilfoil maintains the ability to recover very quickly from cutting. Native plants which cannot recover as readily from the harvesting encounter a selective disadvantage. The end result can be a shift in plant biomass away from more beneficial native plants, toward Eurasian watermilfoil. Whereas Eurasian milfoil can reproduce through fragmentation, the potential for free floating cut plants to spread growth by settling in other parts of the lake also must be considered. Aquatic plant cutters also tend to entrain a large number of small fish, turtles, and other aquatic organisms which will be removed from the lake if not screened out by the operator. Because of these problems weed harvesting has become subject to regulation and permitting by the Indiana Department of Natural Resources. Harvesters are often the only effective option for controlling excessive growths of stout native plants that do not respond well to other control methods. They are also often employed in areas where regulatory permitting excludes the use of pesticides.

•Control of Eurasian watermilfoil and Curly-leaf Pondweed with Aquatic Contact Herbicides:

Several aquatic contact herbicides are available for use in Indiana lakes. Aquatic pesticide applications on Indiana public lakes are subject to review and permitting on a seasonal basis with the Indiana Department of natural Resources. In addition aquatic applicators for hire must be licensed through the office of the Indiana State Chemist. In aquatic herbicide applications chemical products are typically dispersed over target plants as liquid or granular formulations using specialized boat-mounted equipment. Most contact herbicides function by eroding the cell membranes of plant tissue disrupting plant functioning. Control is usually achieved quickly with susceptible plant species often dropping out in less than one week. Aquatic herbicide choices are somewhat limited as EPA approved products must not cause damage to untargeted organisms, provide a hazard to lake users, or leave harmful residues in the environment. Because of these requirements most contact herbicides have a short half-life in an aquatic environment, being lost to soil adhesion, photodegradation, or bacterial decomposition shortly after application. By both accident and design, most aquatic contact herbicides are selectively effective against obnoxious exotic species with Eurasian milfoil, and Curly-leaf pondweed being especially susceptible. Stout native species such as some of the larger native pondweeds and most of the native milfoils largely remain unaffected by open-lake and lake-channel applications. This provides the advantage of allowing selective control, dropping out invasive exotics and leaving the native plant community to recover and capitalize on available light. Selective susceptibility needs to be considered when making herbicide choices so that appropriate plant community effects occur. One disadvantage of contact herbicide use in Wall Lake is the impact on Sago pondweed that was common in some of the lake's plant beds in 2004. Sago pondweed is moderately susceptible to most contact herbicides and is an important food source for many of the diving ducks that frequent Wall Lake in late Fall and Winter. Contact herbicides tend to leave plant root structures intact so regrowth often begins shortly after treatment. Multiple treatments can be needed in some cases to maintain full-season control. Thus far one seasonal contact herbicide application has provided excellent control on Wall Lake's milfoil. Use of some herbicides requires that lake activities such as swimming or lawn irrigation be restricted near the treatment area during a post treatment waiting period. Water-use restrictions generally apply within 100 feet of the application area. Waiting periods for swimming and other water-uses vary between zero and 30 days depending on the product used.

•Aquatic Plant Control with 2-4-D Granular Translocated Aquatic Herbicide:
Granular formulations of 2-4-D herbicide have been used for many years to control Eurasian watermilfoil. In lawn, agricultural, and aquatic applications 2-4-D is used to selectively control plants which are biologically classified as "broadleaves". Aquatic plants in this category include Eurasian and Native milfoils and Coontail *Ceratophyllum echinatum*. 2-4-D is a translocated or "systemic" aquatic herbicide. It is absorbed by target plants and transported through their vascular systems, affecting remote parts of the plant including the root structure. This offers the theoretical advantage of actually killing more plants and providing longer term control. Well-timed 2-4-D applications in some cases provide seasonal control of Eurasian watermilfoil with regrowth occurring the following season. Occasionally reapplication is needed

within the same season. In past seasons the performance of 2-4-D and contact herbicides has been identical on Wall Lake with both providing excellent full-season control. In both cases regrowth has occurred the following season in all areas and new areas as well. With milfoil infestations, 2-4-D offers the advantage of being highly selective for milfoil with the pondweeds, and most other native plants remaining completely unaffected. Granular 2-4-D use typically restricts swimming near the treatment area for one day, and requires a waiting period on the use of lake water for lawn irrigation, so ornamental and garden plants will not be damaged.

•Aquatic Plant Control with Trichlopyr Translocated Aquatic Herbicide:
Available in a liquid formulation as Renovate 3® aquatic herbicide, trichlopyr offers broadleaf specific systemic control of aquatic plants in a liquid herbicide. This offers the advantage of easier handling and application over 2-4-D. Results have been similar to use of 2-4-D. Improved application techniques and the use of adjuvants show some promise of possible providing multi-seasonal control with the use of Trichlopyr. The current labels allows the restricted use of dosed lake water to be adjusted in accordance with lake-water assay results, greatly reducing the time of restriction in most cases.

•Aquatic Plant Control with Fluridone Translocated Aquatic Herbicide:
Two aquatic herbicide formulations containing fluridone are currently available under the trade names Avast!® and Sonar®. Fluridone is an extremely effective aquatic herbicide at very small concentrations in lakes and ponds, while it displays a relatively low toxicity to fish and mammals. Unlike most other aquatic herbicides it's also environmentally persistent, often remaining in the dosed waterbody in minute, but measurable amounts over the course of several months. Fluridone is absorbed by plant shoots from water, and from hydrosoil by the roots of aquatic vascular plants. In susceptible plants, fluridone inhibits the formation of carotene. In the absence of carotene chlorophyll is rapidly photodegraded causing plants to become chlorotic (whiteish) and eventually drop out. Like many other herbicides fluridone is capable of a high degree of selective control at proper dosages. Within the assemblage of plants in Wall Lake, Curly-leaf pondweed and Eurasian watermilfoil are most susceptible. For control of Eurasian milfoil fluridone is introduced into a lake at the calculated rate of six to twelve parts-per-billion. Assays are often performed within the first two weeks after initial dosing to assess a hit or miss on a target concentration. A second dosage is often used to maintain the target concentration for a period of 60 to 90 days as the product is allowed to work. At a 6 PPB dosage rate fluridone is highly selective for Eurasian watermilfoil and Curly-leaf pondweed. Control typically lasts the entire season with occasional carryover effects during the second season. At dosages of 10 to 12 PPB Eurasian watermilfoil control is typically complete by the end of the first season and often extends through the second season, but a variety of native plants may be impacted. One major advantage of Fluridone use is its persistence and slow activity. During the extended treatment period the product mixes throughout the upper strata of the entire lake basin, allowing it to reach all exotic target plants in contact with the water. This also means that consideration must be given to possible impacts downstream from the target lake. Because of its slow rate of activity fluridone also offers the advantage of providing for gradual breakdown of target plants, providing a more gradual release of nutrients than faster acting herbicides. This decreases the chances of developing oxygen deficits or excessive algal blooms in shallow lakes. Because of the high cost of fluridone herbicides, their use is often reserved for lakes with extensive littoral areas showing profound mat-forming infestations and severely

impaired recreational use. The only water-use restriction associated with fluridone is a wait on the use of lake water for lawn and garden irrigation of 14 to 30 days.

•Aquatic Plant Control with Triploid Grass Carp (White Amur):
The Asiatic Grass Carp *Ctenopharyngodon idella* have become popular as an introduced exotic biological control for rooted aquatic plants in ponds and southern U.S. lakes. Grass Carp are native to river systems of Russia and China. The species was first imported to the southern United States in 1963. Like most biological controls herbivorous grass carp have remained extremely popular despite some problems associated with their use. Stocking of grass carp was initially illegal in many states including Indiana. Because grass carp are a possibly detrimental exotic species, resource managers feared a destructive establishment of viable wild populations. This process had already occurred with the common carp which remains a destructive influence in our aquatic habitats. Proponents of the plant-eating fish argued that viable breeding habitat for the carp was not present in the United States. That argument was refuted when viable reproduction was noted in the 1980's in tributaries to the Mississippi. When a technique was developed for producing genetically altered triploid grass carp stock with greatly reduced fertility, laws in many states including Indiana were changed to allow stocking of the sterile fish in private waters. The possibility still exists for fish producers to bypass the necessary hatchery process and market fertile fish. Illegally stocked fertile grass carp have been found in some locations. Use of any grass carp remains illegal in twelve states including Michigan. Despite remaining controversy, some regulatory agencies encourage their use in ponds and lakes publishing stocking guidelines and even offering the fish for sale. Grass carp have been introduced into thousands of private ponds and many larger reservoirs in the southern United States with mixed results. Often stockings in large waterbodies bring either complete eliminations of vegetation or very little decline at all (Cassani 1995). Grass Carp are selective feeders and unfortunately tend to prefer most native plant species over Eurasian watermilfoil. Results of grass carp stocking vary with the plant species assemblage present in stocked waters and variations in lake morphometry. In general, stocking at low rates can be expected to produce a shift in plant biomass away from preferred species food plants, toward unpreferred. At high stocking rates the fish will consume all rooted aquatic vegetation in the system. This causes a shift in plant biomass toward planktonic and filamentous algae as fish waste and feeding activity boosts lake nutrient levels. At sustained high numbers, the fish will consume filamentous algae, emergent aquatic plants, and even terrestrial vegetation within their reach at the lake's edge. Shoreline erosion can become a problem when this occurs. At the end result of sustained high stocking rates lake plant biomass will be maintained in planktonic algae, which the fish are unable to utilize as a food source. This can obviously lead to water clarity problems and unstable oxygen levels, especially in the temperate northern U.S. Successful use of grass carp on ponds and in large southern lakes often trades water clarity for alleviation of rooted plant problems. This technique can be effectively employed where water clarity and high oxygen levels are not a priority. In the case of Wall Lake where water quality and clarity is a high priority, use of herbivorous fish as a management technique would not be wise or legal.

•Benthic Barriers for Aquatic Plant Control

Sheets of plastic or rubber material have been used to exclude aquatic plant growth. Usually owners of small ponds or swimming areas will employ this technique by placing the liner on the bottom and depositing sand or pea gravel on the liner. One drawback with this technique is the tendency for gasses to build up beneath impermeable liner material pushing it up from the bottom. This occurs as decomposition in the lake sediments produces hydrogen sulfide and carbon dioxide gasses. Using mesh liners or permeated liners can alleviate this problem somewhat, but obviously will allow plants to a grow through the liner. Bottom liners also effectively exclude areas of benthic habitat and are generally not permitted by IDNR in public lakes for this reason.

□ Table 2.4-1 Aquatic Plant Management alternatives

Option	Benefits	Drawbacks
No Control	No dollar cost, No water-use restrictions	Further loss of plant diversity, degraded fish & wildlife value, possible further Sportfish stunting, Impeded recreational use, aesthetic problems
Biocontrol Weevils	No swimming restrictions, No watering restrictions	Often ineffective, Cost prohibitive
Biocontrol Grass Carp	No water-use restrictions, possible multi-season control	Results not-predictable, illegal in Indiana public waters, may cause water clarity/quality problems, limited selectivity
Harvesting	No water-use restrictions, Removes some nutrients from lake	May hasten spread Eurasian milfoil through fragmentation and hydrosoil disturbance, Expensive, May result in regrowth within same season, Requires plant disposal site, Non-selective
Benthic liners	No water-use restrictions, possible multi-seasonal control	Impairs benthic habitat, Not generally permitted in Indiana Public Waters, Not feasible in deep water, Inherent maintenance problems
Aquatic Pesticides (2-4-D)	Highly selective control, Very effective	Intermediate expense, difficult application, Swimming and irrigation restrictions, Generally provides one season's control
Aquatic Pesticides(Renovate)	Highly selective control, Very effective	Expensive- materials expense, Swimming and irrigation restrictions, Generally provides one season's control,
Aquatic Pesticides (Sonar a.s.)	Highly selective control, Very effective, Multi-seasonal control	Expensive product, irrigation restriction, possible damage to non-target vegetation
Aquatic Pesticides (contact herbicides) (diquat dibromide or endothols)	Some selectivity, Very effective, fast acting, least expensive application	Generally provides on season's control, Possible regrowth in late season, Swimming, Irrigation, and possible fish consumption restrictions

For the most efficacious control of Eurasian milfoil the plan recommended a 2005 season application of Fluridone aquatic herbicide to Wall Lake at a rate of six parts-per-billion to selectively control Eurasian watermilfoil. This rate of application typically provides full control by the end of the treatment season, often with carry-over control in the second season. Also included in the plan recommendations were follow-up contact herbicide treatments to control eventual regrowth of Eurasian watermilfoil in years two through five of the plan.

An early-season treatment for Curlyleaf pondweed in years two through four was also recommended. Curlyleaf pondweed forms its reproductive structures (turions) very early in the spring season thus providing propogules that can produce plants in the following season well before a treatment for aquatic plants would normally occur. Destroying the plants prior to turion production with an early spring treatment in multiple successive seasons has shown some promise in providing long term control of Curlyleaf by preventing reproduction and depleting the number of propogules present. While Wall Lake does not have a severe problem with Curlyleaf in terms of a major hindrance to the ecology of the lake or lake recreational value, the potential exists for a problem to develop with this invasive plant, especially after resources become more abundant as competition with Eurasian milfoil is reduced. In 2004 the Wall Lake Fisherman's Association applied to the LARE program for cost-share funding to help carry out the plant management plan. A whole lake Fluridone treatment was utilized and provided complete control of Eurasian watermilfoil by the end of the 2005 growing season. With the exception of the reduction of Elodea *Elodea canadensis* (a fluridone sensitive native plant) significant damage to the lakes native plant community was not noted. Because a few healthy milfoil plants were spotted in the lake in September of 2005 the Wall Lake Plant Management Plan was adjusted to allow for treatment of up to five acres of possible Eurasian milfoil regrowth in the 2006 season. (Aquatic Enhancement 12/2005) The Wall Lake Fisherman's Association applied to the LARE program for cost-share funding to continue the plan as amended in 2006. In the spring of 2006 a very low density regrowth of Eurasian watermilfoil was noted to occur over the hatched areas displayed below. Most milfoil plants noted were unhealthy. The plants also appeared to be stunted and did not approach the surface of the lake. Five acres shown below were treated with 2-4, D aquatic herbicide in 2005 based on their support of a slightly higher density of Eurasian watermilfoil than other areas of the lake.

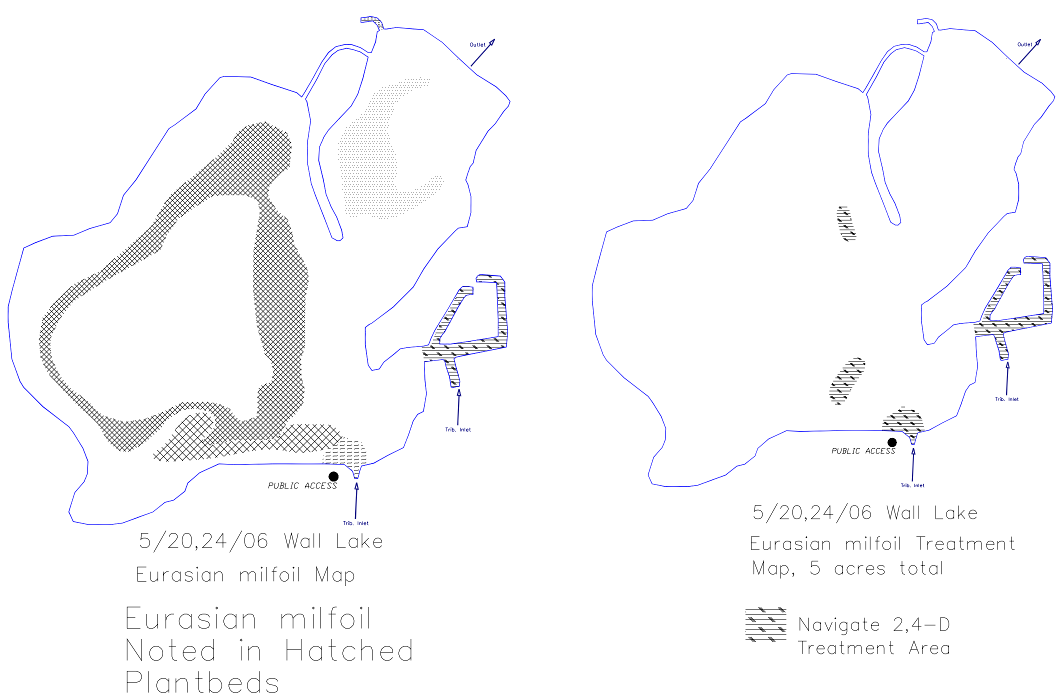


Figure 2.4-1a Plantbeds with a low-density milfoil regrowth in 2005 (left) and treated areas (right)

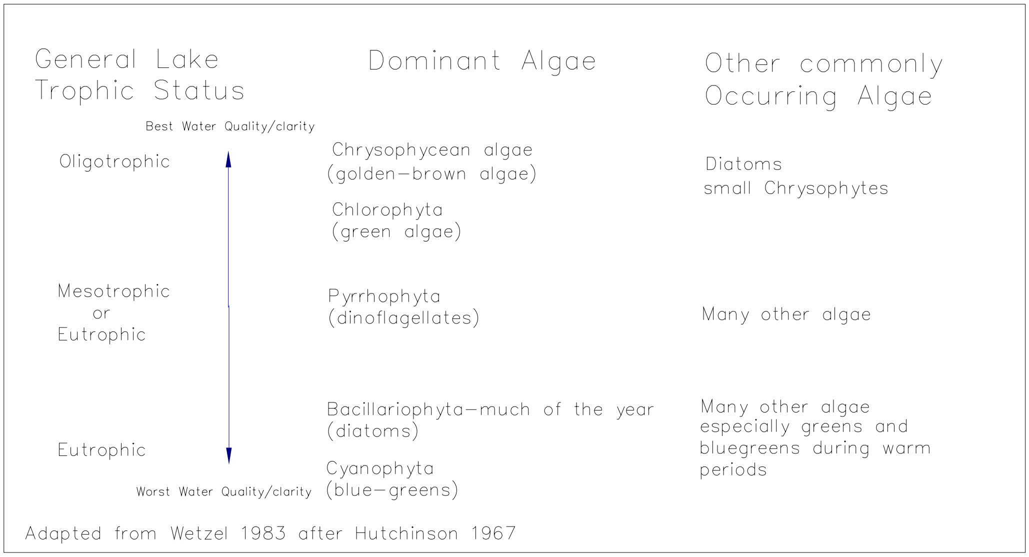


Figure 2.5-1 Relationship of General Algal Dominance to Lake Trophic State

2.5 Phytoplankton

Phytoplankton (microscopic free floating water plants) are important in aquatic systems as the primary producers, forming the most basic trophic level. They can sometimes be useful as indicators of water quality with species compositions being reflective of lake conditions. General planktonic assemblages, however, are subject to wide variations in algal dominance based on large number of environmental variables. Typically, a lake's waters will contain a varied assemblage of algal species with one or more species assuming dominance in response to prevailing environmental conditions. Repeating and predictable seasonal patterns in algal population levels and species dominance are common. This is evident in northern Indiana lakes where the best water clarity often occurs in May and early June, a period in which a lag in algal populations occurs as species dominance shifts from a cold to a warm season algal assemblage. Temporary localized algal blooms have been noted in Wall Lake in mid June and July in recent seasons. Lakewide boosts in algal populations probably partially account for a temporary loss in water clarity after Wall Lake's Eurasian milfoil treatments occur. This can occur in the post treatment period via three primary mechanisms. As target plants decompose the nutrients (primarily phosphorus) incorporated in the plants tissues may become free in the water column for use by Plankton, boosting populations and decreasing water clarity. A significant reduction in plant biomass in the lake can also reduce daylight cover utilized by zooplankton grazers to avoid predation by small fish. The resulting temporary decrease in zooplankton through predation can in-turn allow phytoplankton prey numbers to increase. A significant boost in phosphorus levels can also induce a shift to species of bluegreen algae, a class of algae that is often less palatable to zooplankton and hence less susceptible to their control. Another mechanism of post-treatment turbidity is the leaching of organic acids from decomposing plants. This tends to give the water a dark stained appearance after large milfoil treatments on Wall Lake.

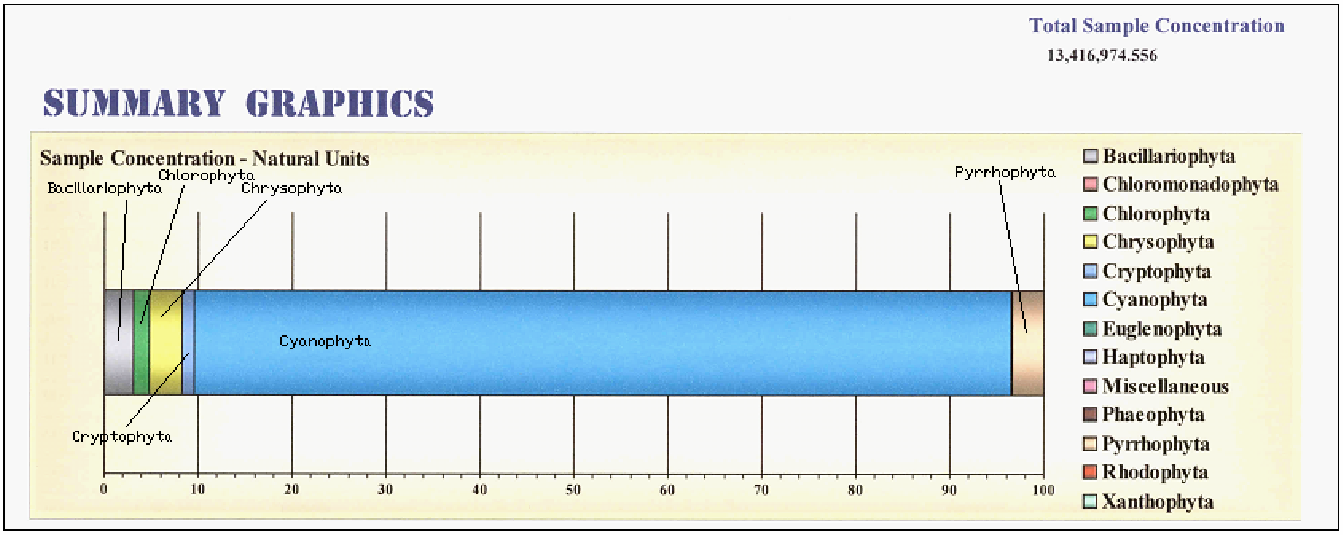


Figure 2.5-2 Composition of Wall Lake Algal Community by Division 8/24/05, Graphic Phychotech, Inc.

To examine the lakes plankton community for this work a plankton sample was collected from Wall Lake utilizing a single vertical tow of a plankton net between the depth of the one percent light level (approx. 10 meters or 34 feet) and the surface on 8/24/05. A total of 108 separate algal species occurred in the sample and were identified to the species level. The number of total algal natural units per liter was 13,416,974.556. The algal population was dominated numerically by the bluegreen algae (division Cyanophyta) at 86.85%. Bluegreens are common and often dominant in Phosphorus rich lakes. The second most common algal division in Wall Lake was Chrysophyta (golden-brown algae) at 3.63%. Chrysophyta commonly occur in low nutrient lakes or seasons of lowered nutrients in moderate or nutrient rich lakes. Pyrrhophyta (the dinoflagellates) often prominent in lakes of intermediate nutrient enrichment, was the third most numerous division at 3.34%. Bacillariophyta (the diatoms) was the fourth most numerous at 3.14%. Diatoms are most common in low nutrient waters. Blue green dominance can often be an indicator of high phosphorus levels. Shifts to bluegreens occur in response to nutrient enrichment as high phosphorus levels allow nitrogen to become the primary growth limiter. As nitrogen fixers bluegreens are not as dependant on dissolved nitrogen as other alga and enjoy a selective advantage in highly eutrophic lakes during the summer months.

Algal Division	Wall Lake 8/24/05 Sample Concentration (Natural Units/L)	%
Cyanophyta	11,652,622.65	86.85%
Chrysophyta	487,171.795	3.63%
Pyrrhophyta	447,671.379	3.34%
Bacillariophyta	421,337.768	3.14%
Chlorophyta	210,668.884	1.57%
Cryptophyta	171,168.468	1.28%
Euglenophyta	26,333.611	0.20%
Haptophyta	0	0.00%
Miscellaneous	0	0.00%
Phaeophyta	0	0.00%
Rhodophyta	0	0.00%
Xanthophyta	0	0.00%
Chloromonasophyta	0	0.00%
Total	13,416,974.56	100.00%

Table 2.5-1 Natural Units per Liter by Algal Division in Wall Lake

With a surface water total phosphorus level measured below a lab detection limit of only .007PPM (mg/L) in Wall Lake in August of 2005, it's not very likely that high phosphorus levels were responsible for blue green dominance. The small size of many of the counted bluegreen natural units probably overstates dominance that would otherwise be less complete in terms of biomass. Selective grazing by zooplankton may also be of significance in the bluegreen dominance. Phytoplanktivorous zooplankton avoid grazing on most bluegreen species because of planktonic toxins or unpalatability. Plankton sampling was performed on Wall Lake by the Indiana University School of Public and Environmental Affairs for the Indiana Department of Environmental Management in 1973, 1989, 1997, and 2002. Counts from those years also showed the bluegreen algae to have higher counts than the other algal divisions but only the 1997 data showed algal dominance by bluegreens (defined as 500,000 NU/L). The main reason for the high bluegreen counts in 2005 probably lies in improved counting and identification techniques used over the majority of past plankton counts taken on Wall Lake. Smaller planktonic organisms identified and counted in the 2005 data by Phychotech Inc. would have been excluded from the previous data. The large algae counts and bluegreen dominance independently boosted Wall Lakes Indiana Trophic State Index score for 2005 well beyond past figures, while other parameters showed excellent water quality. This should be taken into consideration when interpreting these results. *Cylindrospermopsis raciborskii*, a potentially toxic non-native blue green alga that has caused problems on some Indiana lakes was not found in the sample. The sampling net mesh size used (250 microns) was not intended to specifically screen for this small algal species, but it would have likely been identified in the sampling if it had been present at a high density.

3. Phosphorus and Water Quality in Wall Lake

With regard to water quality phosphorus is studied and measured more than any other nutrient. A huge volume of literature exists on the fate and effects of increased phosphorus levels in living aquatic systems. This is because relatively small changes in phosphorus levels can have profound effects on an aquatic ecosystem, with changes in functioning at all trophic levels. Phosphorus levels boosted slightly by internal or external loading can often quickly boost algal populations and cause blooms associated with poor water clarity. This is because phosphorus is typically the limiting factor in the growth of planktonic algae. An algae "bloom" is a rapid increase in algal populations in a short period of time. Repeated algae blooms or an elevated biomass of algae over a long period of time has ramifications at all levels of ecosystem functioning. More immediately evident is the destruction of water clarity, quickly affecting the aesthetic and recreational value of a lake. The term "eutrophication" is often used to describe increasing phosphorus levels accompanied by corresponding higher primary productivity. To some extent natural lakes like Wall undergo eutrophication naturally over time as soil and organic materials migrate to these depressions in the landscape driven by rainfall, wind, and snow-melt runoff. The materials become committed to the lakes sediments and eventually lead to a filling-in and finally succession into a bog or wetland, and ultimately upland. Examples of glacial depressions in each of these states can be found in Lagrange County. Human land uses and urban development can be said to simply hasten this process of natural "eutrophication" or lake succession. However, a human induced rapid introduction of soil borne and dissolved pollutants takes place in a mere millisecond on the geological time scale that would typically govern this process outside human influence. Because of this, ecosystem adjustment does not occur as it naturally would, and systems can become unstable, exhibiting signs of disturbance, shifts to disturbance oriented species, and unstable water chemistry and fish populations. It is often useful to classify lakes by their degree of eutrophication, taking one or more chemical or biological characteristics as a measure of lake character. The terms outlined in the table below are often useful for this purpose.

Table 3-1 Basic Classification of Lakes based on "trophic" condition (biological productivity) (adapted from Jones 1996)

Oligotrophic- clear water, very low levels of nutrients (total phosphorus <.006ppm) support few algae, dissolved oxygen is present in the hypolimnion, can support salmonid (trout and cisco) fisheries.

Mesotrophic- water less clear, moderate levels of nutrients (total phosphorus .01-.03ppm), support healthy algal populations, decreasing dissolved oxygen in the hypolimnion, loss of salmonids.

Eutrophic- transparency less than two meters, relatively high concentrations of nutrients (total phosphorus >.035ppm, no dissolved oxygen in hypolimnion during summer, weeds and algae abundant.

Hypereutrophic- transparency less than 1 meter, no dissolved oxygen in hypolimnion, extremely high nutrient concentrations (total phosphorus > .08ppm) support thick algal scums, very dense weeds.

3.1 The Indiana Trophic State Index

The Indiana Trophic State Index is a multi-parameter eutrophication index developed in the early 1970's as a tool to characterize problem Indiana lakes and define the reasons or sources behind complaints from lake users. (Jones 1996) In the mid 1970's the ITSI began to be used as a means of numerically ranking Indiana public lakes. Data is collected and scored according to the following table:

Table 3.1-1 The Indiana Trophic State Index

Parameter & Range	Eutrophy Points	Wall Lake 05 Results	Points
Total Phosphorus (mg/L or PPM) mean of epilimnion & hypolimnion			
A. AT LEAST .O3	1		
B. .04-.05	2		
C. .06-.19	3	.0725	3
D. .2-.99	4		
E.1.0 OR MORE	5		
Soluble Phosphorus (PPM)mean of epilimnion & hypolimnion			
A. AT LEAST .O3	1	0.006	0
B. .04-.05	2		
C. .06-.19	3		
D. .2-.99	4		
E.1.0 OR MORE	5		
Organic Nitrogen (PPM)mean of epilimnion & hypolimnion			
A.AT LEAST .5	1		
B. .6-.8	2		
C. .9-1.9	3		
D. 2.0 OR MORE	4	2.72	4
Nitrate (PPM)mean of epilimnion & hypolimnion			
A. AT LEAST .3	1	<0.01	0
B. .4 TO .8	2		
C. .9 TO 1.9	3		
D. 2.0 OR MORE	4		
Ammonia (PPM)mean of epilimnion & hypolimnion			
A. AT LEAST .3	1	0.28	0
B. .4 TO .5	2		
C. .6 TO .9	3		
D. 1.0 OR MORE	4		
Dissolved Oxygen: Percent saturation at 5 feet from surface			
A. 114% OR MORE	0	96%	0
B. 115% TO 119%	1		
C. 120% TO 129%	2		
D. 130% TO 149%	3		
E. 150% OR MORE	4		
Dissolved Oxygen: Percent of water column with at least .1PPM			
A. 28% OR LESS	4		
B. 29% TO 49%	3		
C. 50% TO 65%	2		
D. 66% TO 75%	1	70%	1
E. 76% TO 100%	0		
Light Penetration (Secchi disk)			
A. FIVE FEET OR LESS	6		
B. GREATER THAN FIVE FEET	0	13.1	0
Light Transmission (photocell)-percent light transmission at 3ft			
A. 0 TO 30%	4		
B. 31%-50%	3		
C. 51%-70%	2	67.75	2
D. 71% AND UP	0		
Total plankton per liter sampled from a single vertical tow between			
the 1% light level and the surface			
A. Less than 3000 organisms/L	0		
B. 3000-6000	1		
C.6001-16000	2		
D. 16001-26000	3		
E. 26001-36000	4		
F. 36001-60000	5		
G. 60001-95000	10		
H. 95001-15000	15		
I. 150001-500000	20		
J. Greater than 500000	25	13,416,974.56	25
K Blue Green Dominance: additional points	10	10	10
0 to 25 points Oligotrophic, 26-50 Mesotrophic, 51-75 Eutrophic		Wall Lake 05 Total Pts	45

The ITSI score for Wall Lake in 2005 was 45 Eutrophy points. This places Wall Lake in the "mesotrophic" category, indicating it's a lake of intermediate nutrient enrichment. The majority of the Eutrophy points in the 2005 score resulted from the high blue green algae counts. As earlier stated, this is probably a result of improved accuracy in algal counting and identification over techniques used when the ITSI was developed. With a Secchi depth of four meters (13.1 feet) and total phosphorus below a lab detection limit of .007 parts-per-million, Wall Lake in reality probably belongs at the upper end of the Mesotrophic category or lower end of the Oligotrophic (low nutrient) category. Sampling was done after a droughty spring and early summer in 2005 when the lake had received little recent runoff, so nutrient levels and water clarity may actually have been slightly better than average for Wall Lake.

3.2 Historical water quality on Wall Lake

Scores generated for Wall Lake in 1973, 1989, 1997, and 2002 were 13, 5, 19, and 8 respectively. If we dismiss the points resulting from the plankton count in 2005 we get a score of 20 for 2005.

Table 3.2-1 Indiana Trophic State Index Scoring for Sampled Years on Wall Lake

Parameter Category	9/6/73 points	7/4/89 points	8/24/92 points	8/19/97 points	7/29/02 points points	8/24/05 points
Total Phos.	0 <.03/<.03	1 (.032).013/.038	2 .017/.042	2 (.04).015/.05	1 (.032ppm).016/.048	3 (.0725ppm) <.007/.145
Soluble Phos.	0	0	0	0	0	0
Organic Nitrogen	1	0	2	3	2	4
Nitrate	0	1	1	0	0	0
Ammonia	2	0	3	0	0	0
D.O. % sat. at 5 foot depth	0	0	0	0	0	0
D.O. % water column oxic.	0	0	0	1	1	1
Secchi	0	0	0	0	0	0
% light trans. @ 3 ft	0	2	3	3	3	2
Plankton per liter	10	1	2	0	1	25
Blue Green Dominance	0	0	0	10	0	10
Total	13	5	13	19	8	45

In looking at the scores alone an obvious degradation in water quality is not evident, however Wall Lake's phosphorus measurement in the hypolimnetic (lake bottom) water sample was much higher in 2005 than in past sampling. In 1997 through 2005 Wall Lake also had less oxygen in the hypolimnion than in the first two seasons sampled. This can occur as dead planktonic organisms or other detritus accumulate in the hypolimnion and create an oxygen drain as they are decomposed by aerobic (oxygen utilizing) bacteria. Mean water column organic nitrogen has also been higher in the last three seasons sampled, with the highest measurements being recorded in 2005 (2.16 ppm epilimnion, 3.28 ppm hypolimnion). The Lagrange County health department conducted a study of county lakes using data collected from 1988 to 1991. (Lagrange 1991) They noted relatively low nutrients in Wall Lake surface waters (.05ppm) compared to other lakes in the county, scoring it fourth out of 25 sampled lakes in terms of water quality. However, it was noted that there appeared to be pressure on the lake's oxygen concentration that was probably attributable to development and general poor conditions for septic systems. The increased oxygen drain in the hypolimnion, elevated organic nitrogen, and the unusually high hypolimnion total phosphorus measured in 2005 are the parameters that seem to indicate a possible degradation. A possible explanation for the elevated hypolimnetic phosphorus in 2005, if anomalous, is the inadvertent suspension of detritus from the bottom of the lake during sampling or the capture of free floating detritus in the sample. Other possible seasonal variables in 2005 include the whole lake herbicide treatment for control of Eurasian watermilfoil. Typically whole lake fluridone treatments like the 2005 treatment take effect so slowly that they produce little or no effect on limnological parameters but it cannot be dismissed as a possible cause. A mechanism for such a relationship is not obvious since a large milfoil biomass would primarily draw its nutrients from the hydrosoil rather than the water column. Even if the milfoil plants or an associated planktonic community was drawing a significant amount of phosphorus from the water column the window to sequester the lakes nutrients seasonally in this way would be short, since much of the plant growth takes place after thermal stratification has begun to cease nutrient exchange with the Hypolimnion where most phosphorus was in the summer of 2005. Since the lake’s pre-milfoil native plant community did not appear to have a large plant biomass like the milfoil infestation, it would follow that we might expect to have a similar hypolimnetic nutrient content before the milfoil if the Eurasian milfoil was annually holding the nutrients seen in the Hypolimnion in 2005. In any case, the more natural nutrient cycling regime associated with a stable native plant biomass will likely be more beneficial to Wall Lake in terms of water quality than the boom and bust practice of a large annual treatment with fast acting contact or systemic herbicides. At present whole-lake treatments are probably the only reliable way to reduce and maintain milfoil growth biomass in accordance with the desire of most lake users while still minimizing the acute release of nutrients often associated with other treatment types. Wall Lake did not experience an algae bloom or decrease in water clarity in response to the fluridone treatment in 2005.

Date Sampled	9/6/73	8/24/75	7/4/89	8/24/92	8/19/97	7/29/02	8/24/05
Depth (ft)	28	33	28	28	28	28	29.5
Hypolimnetic Total Phos.	<.03	.06	.038	.043	.05	.048	.145

Table 3.2-2 Sampling Dates, Depths and Hypolimnetic Total Phosphorus Measurements From Wall Lake

Ordinarily we would look for a more pronounced change in water chemistry with a treatment that works more quickly like those performed in past seasons. Unfortunately none of the sampling seasons on Wall Lake has coincided with a 2, 4-D or Diquat Dibromide treatment. The association opted to try harvesting the plants in 2002 when SPEA sampling last occurred. A basic yearly sampling regime for nitrogen, phosphorus, and oxygen can help make the data set more complete.

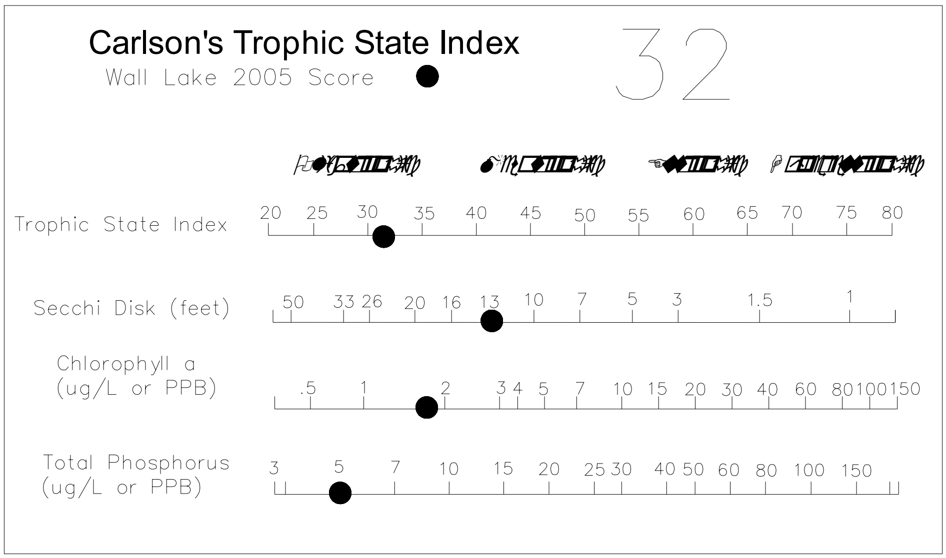


Figure 3.3-1 Carlson's Trophic State Index

3.3 Carlson's Trophic State Index

Carlson's Trophic State Index is another very commonly used multi-parameter index. The index scores three commonly measured parameters on a scale produced from the set of lakes used to form the index. This can be useful in revealing variations in parameter relationships within a particular lake in comparison with Carlson's lake set. Because the total phosphorus measurement was below a lab detection limit of 7 part per billion it's necessary to estimate the total phosphorus concentration for Carlson's Index. We can see that Wall Lake's water clarity lags significantly behind Carlson's lakes of similar total phosphorus and also lags somewhat in chlorophyll a. Chlorophyll a is an algal pigment, the measurement of which provides a rough measure of algal biomass. This relationship suggests that something other than algae may provide a significant hindrance to light on the water column in Wall Lake. In Wall Lake this is most likely precipitating marl (calcium carbonate) or suspended sediments.

3.4 The Wall Lake Water Budget

To quantify sources and losses of water for Wall Lake and provide a figure for hydraulic retention time, a water budget was produced. The calculation of the respective water budget components is outlined below.

Direct Rainfall Input

Yearly direct precipitation to the lakes was calculated using Angola rainfall records obtained from the Midwestern Regional Climatic Center in Champaign, Illinois. Mean annual precipitation of 38.89 inches for the period 1990 to 2001 was used.

	1990-2001 Records	
Surface Area (acres)	Mean Annual Precip.(in)	Ann. Direct Precip. Vol. (acre-feet)
141	38.89	456.96

Table 3.4-1 Calculation of Direct Precipitation

Surface Runoff Input

Because there is no U.S. Geological survey operated a stream-flow gauging station on the Wall Lake, outlet outflow data from another nearby watershed of similar soil types and precipitation was used to calculate contributions to the water budget from surface runoff. The U.S.G.S. operated a stream-flow gauging station on the outlet from nearby Lime Lake between 1969 and 1986. This provided outflow data specific to the same general watershed (Fawn River). A mean annual outflow figure for the period of record provided a starting point for runoff calculations. Runoff for the entire 17.5 square mile watershed was recorded at 6.25 inches annually. Dividing the runoff figure by mean annual precipitation for the same period of record produced a runoff coefficient of .17. Annual outflow for the period 1989 to 1999 was predicted at 6160 acre-feet with the U.S.G.S. coefficient. Because the U.S.G.S. outflow figure omits runoff that evaporates on that watershed's lakes, and includes direct rainfall to the lakes, the predicted outflow was adjusted by those amounts and a refined runoff coefficient of .14 was generated.

This coefficient was then utilized in predicting the drainage from the 612 acres of land in Wall Lake's watershed at 277.67 acre feet of water.

Watershed	Watershed Land Acreage	Ann. Drainage Vol. (acre-feet)
Wall Lake	612	277.67
Runoff Coefficient	0.14	
Annual Rainfall (in)	38.89	

Table 3.4-2 Calculation of Watershed Drainage Volume

The calculations estimate that approximately 62% of Wall Lake's water is contributed by direct rainfall, while the remaining 38% results from rainfall or snow melt runoff from watershed lands.

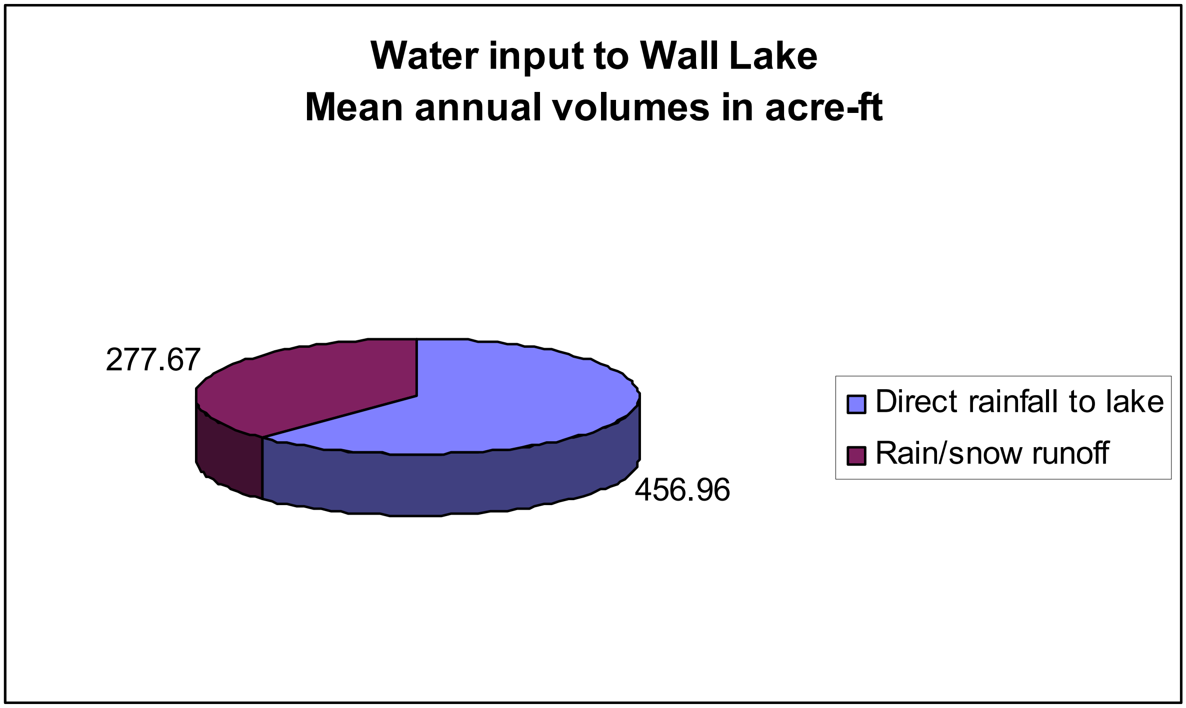


Figure 3.4-1 Annual Water Input to Wall Lake

Wall Lake Water Input	Mean annual volume (ac-ft)	Percentage
Direct rainfall to lake	456.96	62.20%
Rain/snow runoff	277.67	37.80%
Total Water Input	734.6321	100.00%

Table 3.4-3 Wall Lake Water Input

Mean Annual Evaporative Losses

Evaporative losses for the lake were estimated using pan evaporation data for Prairie Heights Indiana obtained through the National Climatic Data Center in Asheville North Carolina. Mean annual pan evaporation for the year of most complete record (1996) was 31.11 inches. Because actual evaporative losses from lakes occurs at approximately .74[1] the rate of standard measured pan evaporation, this figure was adjusted to 23.02 inches and used to calculate mean annual evaporative losses for the 141 acre surface area of Wall lake.

Surface Area (acres)	Mean Annual Evap.(in)	Annual Evap. volume (acre-feet)
141	23.02	270.49

Table 3.4-4 Calculation of Annual Wall Lake Evaporation

[1] .74 is mean of data reported in (Linacre 1994)

Wall Lake Water Losses	Mean annual Volume (ac-ft)	Percentage
Evaporation	270.49	36.82%
Overflow to Brown Lake	464.15	63.18%
Total Losses	734.63	100.00%

Table 3.4-5 Wall Lake Water Losses

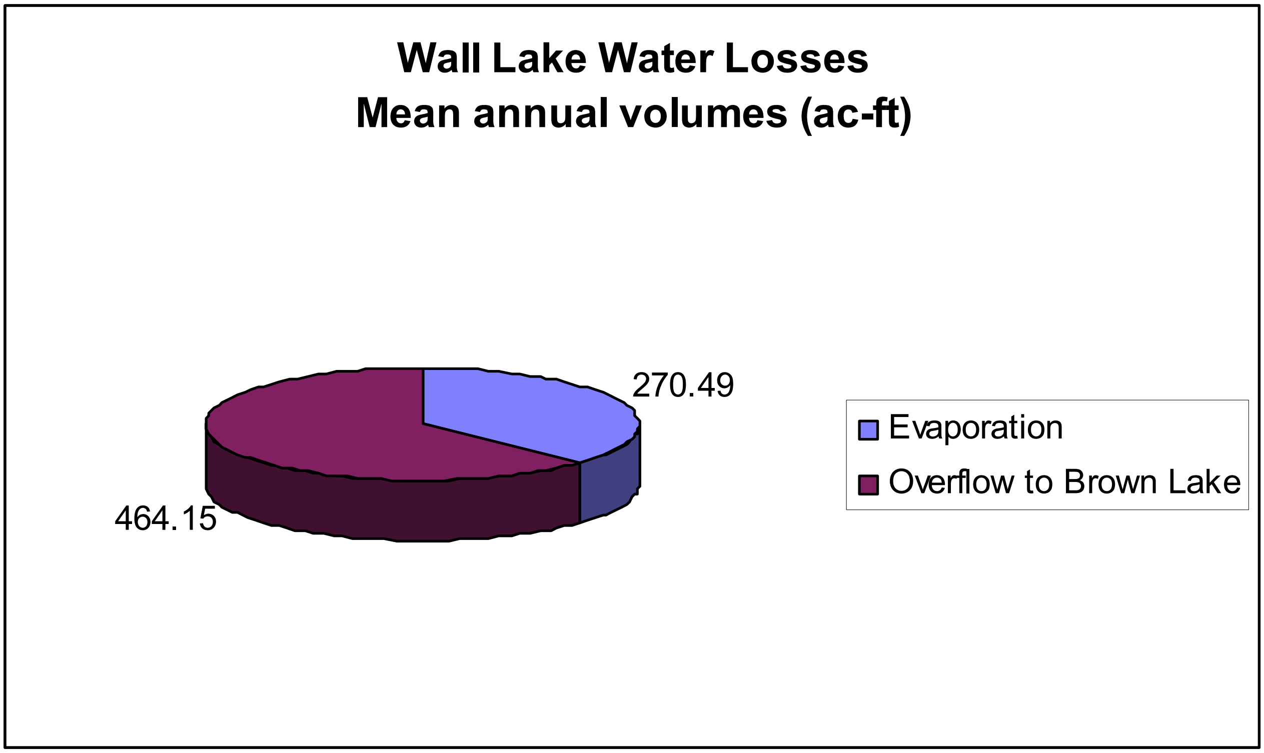


Figure 3.4-2 Annual Water Losses from Wall Lake

Wall Lake's Hydraulic Residence Time

Using the outflow data for Wall Lake a hydraulic residence time (lake volume divided by annual outflow) was calculated. The residence time indicates, on average, the length of time waters spend in the lake once they enter. With a relatively small drainage area Wall Lake has a residence time of approximately 3.52 years.

Lake	Volume (acre-feet)	Mean Ann. Outflow (ac-ft)	Hydraulic Residence time (years) (volume / mean annual outflow)
Wall Lake	1635.81	464.15	3.52

Table 3.4-6 Calculation of Wall Lake's Hydraulic Residence Time

This is relatively long for a Midwest lake. This could make Wall Lake relatively slow to respond to increases or decreases in nutrient runoff from the watershed. This could also make Wall slow to recover from nutrient enrichments from sources that are not dependant on rainfall such as input from septic systems.

3.5 Phosphorus budget for Wall Lake

To optimize the efficacy of watershed changes to be undertaken to reduce nutrient and sediment loading it is helpful to estimate phosphorus inputs to the lake from various sources. Mathematical models were used to estimate phosphorus contributions to Wall utilizing existing demographic, land-use, soil, and water budget data. Calculation of the components of the phosphorus budget is outlined below.

•Estimated Phosphorus Loading from Lakeside Septic Systems

Annual total phosphorus (P) loading for Wall Lake from septic systems was estimated using basic demographic information and a count of lakeside homes from recent air photos. Estimated annual phosphorus contributions to the lake from septic systems were calculated with the following equation:

Annual P load (kg) = (person-years)(wastewater phos. per person yr)(.59)

Where: •person-years =[(3.5 average occupants per household)(average days at lake per yr)]/365
55 days at the lake per year was used for vacation homes (est. 100), 365 days for year round lake homes (est. 37). Vacation home users were assumed to use their lake property during summer weekends and vacation periods totaling approx.55 days annually.

•wastewater phos. per person year = average mass of phosphorus in wastewater produced per person in one year, 1.48 kg (Reckhow 1980[2])

•.59 allows for 41% retention of phosphorus in the soil (Metcalf etal 1979[3])

Summing the respective calculated annual phosphorus loads for the vacation homes and year-round homes on Wall Lake yields and estimated annual phosphorus load of 159.13 kilograms per year. Placing the homes around Wall Lake on a centralized collection system that transports

Septic Load								
part-t	residents/per	days per yr	capita days	Cap-years	P. pr cap-yr	Total P	reten. coeff	ann. P. (kg)
100.00	3.50	55.00	19250.00	52.74	1.48	78.05	0.59	46.05
full time	residents/per	days per yr	capita days	Cap-years	P. pr cap-yr	Total P	reten. coeff	ann. P. (kg)
37.00	3.50	365.00	47267.50	129.50	1.48	191.66	0.59	113.08
							total load	159.13

Table 3.5-1 Calculation of the Annual Phosphorus load to Wall Lake from Lakeside Septic Systems

waste outside the watershed can eliminate this portion of the Wall Lake phosphorus budget and will be a recommendation of this report.

•Estimated Phosphorus Loading from Watershed Runoff

2 mean of reported data pp. 89
3 as reported in Reckhow 1990

A large component of lake phosphorus loading in Indiana is typically contained in watershed runoff (non-point source pollution). Most phosphorus in rain and snow melt runoff typically enters the aquatic system either attached to soil particles, or dissolved in inflowing waters. In Indiana's agricultural watersheds the soil attached component often represents the bulk of phosphorus introduced. For this reason reduction of soil erosion is often a critical component of watershed management. The use of conservation tillage or "no till" farming has helped greatly in reducing the soil attached component by leaving crop residues on the soil surface where they inhibit erosion. This can, however, boost the dissolved nutrient runoff component as decomposing crop residues on the soil surface yield dissolved nutrients. For this study, the soil-attached and dissolved phosphorus components of the phosphorus budget were estimated separately, to produce a clearer picture of relative contributions. The soil attached component of the phosphorus budget was calculated using the following equations:

Sediment Attached Nutrient Load (Reckhow 1990)

$LS_k = 0.001\ Cs_k\ X_k\ SD_k$

Where: LS_k = annual sediment attached nutrient load for area k (kg)
0.001 is a units conversion constant
Cs_k = concentration of nutrient in eroded soil from area k(mg/kg) Calculated from regional data (Mills et al. 1985)(Haith and Tubbs 1981).
X_k = soil loss from area k (tons/ha/year) Calculated using Universal Soil Loss Equation Below (Wischmeier and Smith 1978)
SD_k = sediment delivery ratio (dimensionless) Estimated by Drainage Area (SCS 1983)

Universal Soil Loss Equation (Wischmeier and Smith 1978)

$X_k = 1.29\ \ RE\ \ K\ \ LS\ \ C\ \ P$

Where: X = Soil Loss (tons/hectare/year)
1.29 is a units conversion constant
RE = rainfall erosivity (MJ-mm/ha-h) Calculated value of runoff & rainfall erosive energy, regional value from Steuben NRCS
K = soil erodibility (dimensionless) Mean of Steuben soil type K values from NRCS (Steuben County Soil Survey 1979)
LS = topographic factor (dimensionless) quantifies land slope and length, values used are mean LS by soil type supplied by Steuben NRCS
C = cover and management factor/ cropping factor, quantifies erosion resistance from plant canopy, crop residues, etc. Steuben county agricultural values from Steuben NRCS. Non-agricultural cover factors from (Wischmeier 1978)
P = supporting practice factor, quantifies effect of protective practices of contouring or terracing, the value of 1 was used in the absence of these.

Wetland and pond filtration of Wall Lake's runoff may mediate the soil attached nutrient component of the lakes phosphorus budget. It's likely that some component of soil runoff remains in the wetlands indefinitely, but wetlands sometimes act as a source for nutrients in addition to sometimes acting as a sink. Often a component of soil attached and dissolved nutrients entering the wetland in the spring and summer may become incorporated into the tissues of growing plants, or settle in the wetlands attached to calcium carbonate (marl) that precipitates in the wetlands in response to the growth of submersed aquatic plants and algae. However a component of these nutrients will also re-mobilize as plant materials senesce and decompose in the fall and winter releasing phosphorus. This can be important in changing the timing of nutrient introductions so they have less impact on the lake during the growing season when water quality is more reflective of increased nutrients and also more critical in terms of the lakes biology and recreational value. Because the net effect of this on the lakes annual phosphorus load is difficult to determine, for the purposes of this study the net annual loss of nutrients in the ponds or wetlands is assumed to be negligible.

Cropping	Square Ft.	Acres	Hectares	Constant	RE	K	LS	C	P	Soil Loss tn/yr
C-B	13166010	302.25	122.32	1.29	140.00	0.27	1.05	0.100	1.00	626.26
C-B-W	4388670	100.75	40.77	1.29	140.00	0.27	1.05	0.088	1.00	183.70

Table 3.5-2 Estimation of Annual Soil Loss from Wall Lake Watershed Agricultural Lands

Because field by field analysis is beyond the scope of this report, agricultural fields in the watershed were assumed to be in typical farming practices in the area. Specifically in 75% Corn-Beans rotation and 25% Corn-Bean-Wheat crop rotation with Corn being field cultivated/residue incorporated and no-till farming during bean and wheat seasons. The model indicates that approximately 626 tons of eroded soil would be lost from the corn-bean rotation areas and 184 tons of soil would be lost from the corn-bean-wheat areas. The total is 810 tons. This is estimated to result in 62 kilograms of soil attached phosphorus being delivered to Wall Lake from agricultural areas. County soil and water conservation district and local USDA Natural Resources Conservation service personnel can work with the Wall Lake residents and area farmers to employ methods for reducing the production and delivery of soil attached nutrients to Wall Lake. Since soil losses from the other land-uses in the Wall Lake watershed are expected to be minimal an equation for estimating dissolved nutrient loading will be applied to those areas. This same equation will also be used to establish an estimated dissolved phosphorus runoff component for agricultural areas. Dissolved Nutrient Loading in the Wall Lake watershed was estimated using the following equation:

Dissolved Nutrient Load (Haith and Tubbs 1981)(Mills et al. 1985)

$LD_k = 0.1\ Cd_k\ Q_k\ A_k$

Where: LD_k = The dissolved nutrient load (kg) from each source area k

0.1 is a units conversion contant

Cd_k = average nutrient concentration in runoff from land-use k in mg/l (Reckhow 1990)

Q_k = surface water runoff from area k (cm) Calculated using annual rainfall and land-use runoff coefficients(Dunne et al. 1978 & Chow et al. 1988 as adapted by Reckhow 1990)(Camp et al 1988 as adapted by Reckhow 1990)

A_k = area of k (ha)

Land Use	Sq ft	acres	hectares	constant	Nutrient con.	Ann Prec. cm	Runoff coef	Ann load kg
Ag, hay/crp		0.00	0.00	0.10	0.15	99.09	0.10	0.00

Ag,C,cb	6583005	151.13	61.16	0.10	0.26	99.09	0.15	23.63
Ag,B,cb	6583005	151.13	61.16	0.10	0.80	99.09	0.15	72.72
Ag,C,cbw	1461427	33.55	13.58	0.10	0.26	99.09	0.15	5.25
Ag,B,cbw	1461427	33.55	13.58	0.10	0.80	99.09	0.15	16.14
Ag,W,cbw	1461427	33.55	13.58	0.10	0.80	99.09	0.15	16.14
Wetlands	3005640	69.00	27.92	0.10	0.01	99.09	0.10	0.28
Developed	2570040	59.00	23.88	0.10	0.38	99.09	0.22	19.78
Wooded	3528360	81.00	32.78	0.10	0.01	99.09	0.10	0.29

Table 3.5-3 Estimation of Annual Dissolved Phosphorus Contributions from Wall Lake Watershed Land Uses

Land Use Codes: Ag = agriculture, crp= conservation reserve program (grasses), C= currently in corn, B= currently in beans, W = currently in wheat, cb = corn bean annual rotation, cbw = corn-bean-wheat rotation. Distribution based on Steuben County NRCS figures and field observation. Ann Prec. cm = annual precipitation in centimeters. Runoff coef= runoff coefficient

The model estimates the annual delivery of 154 kilograms of dissolved phosphorus to Wall Lake from combined watershed runoff. The largest source in terms of dissolved phosphorus is no-till aglands at 73 kilograms. Because no-till farming leaves decomposing crop residues on the surface, dissolved nutrient yields can be higher with this type of agriculture. Soil-attached nutrient yeilds are typically lower than with tilled fields. Field cultivated (a type of tilling) agricultural lands are estimated to be the second highest contributor at 24 kilograms annually. Residentially developed lakeside lands are also estimated to be a significant contributor at 20 kilograms annually. Much of this contribution probably results from the fertilization of turfgrass. Wetlands and Wooded lands are estimated to be insignificant contributors with an annual contribution of less than a single kilogram. Strategies for reducing the delivery of dissolved phosphorus to Wall Lake will be among the recommendations of this report.

•Estimated Phosphorus Loading from Atmospheric Sources

Direct atmospheric loading of phosphorus to a lake's surface occurs both from the deposit of dry windborne dusts, and rain scavenged particulates and soluble gases. Seasonal variability is high with peak deposits typically occurring during spring and fall agricultural fertilization and tillage. (Andren et al., 1977) Atmospheric deposits to Wall Lake were estimated by applying the experimentally determined atmospheric deposition data for another Midwest agricultural watershed to the Wall Lake watershed area.

Atmospheric			
Watrsh acre	Watrsh hec	P per hec kg	Total load (ann kg)
612.00	244.80	0.125	30.60

Table 3.5-4 Estimation of Annual Atmospheric Phosphorus Contributions to Wall Lake

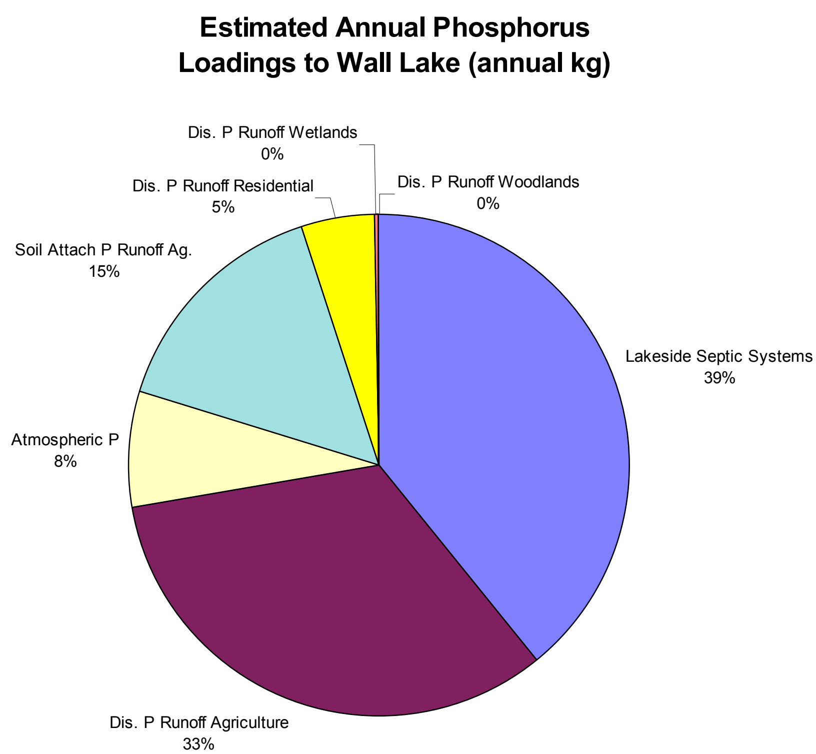
Using an atmospheric total phosphorus input rate of .125 kg/ha/yr (Burwell et al 1975[4]) for the 612 acres of land in the Wall Lake watershed produced annual atmospheric loadings of

4 as reported in Reckhow 1980

approximately 36 kilograms. Atmospheric phosphorus can be limited by utilizing agricultural, construction, and road maintenance practices that minimize wind erosion and the suspension of dusts.

Source	Annual Phos. Load (kg)	Annual Phos. Load %
Lakeside Septic Systems	159.13	42%
Dis. P Runoff Agriculture	133.89	36%
Atmospheric P	30.60	8%
Soil Attach P Runoff Ag.	62.37	8%
Dis. P Runoff Residential	19.78	5%
Dis. P Runoff Wetlands	0.28	0%
Dis. P Runoff Woodlands	0.29	0%
Total	375.16	100%

Table 3.5-5 Estimated Annual Phosphorus Loadings to Wall Lake



Graph 3.5-1 Percentages of Annual Phosphorus Loadings to Wall Lake

The estimates indicate that the majority of Wall Lake's phosphorus load (39%) is contributed by lakeside septic systems (see graph 3.5-1). Contributions of dissolved and soil attached phosphorus from Agricultural lands are also significant at 33 and 15 percent respectively. At five percent and eight percent respectively atmospheric fallout and residential runoff are also significant portions of the budget. The single largest step that could be taken to protect water quality at Wall Lake and limit phosphorus contributions would be to place lakeside residents on a centralized sewage collection system to eliminate septic systems as a source of nutrients. Wall Lake residents are currently working toward accomplishing this goal. Strategies and sources of assistance for limiting each of the components of the Wall Lake phosphorus budget will be included in the recommendations of this report.

• Predicted Phosphorus Concentration for Wall Lake
Utilizing the estimated annual phosphorus loading, and other limnological data, a prediction of long-term average in-lake phosphorus levels can be made. (Vollenweider 1975) defined the following relationship:

$$P = \frac{Lp}{10 + z\rho}$$

Where: **P** =mean summertime in-lake concentration of total phosphorus (mg/L)
Lp = areal phosphorus loading (g/m^2 lake area per year)
10 is a constant
z = mean depth
ρ = hydraulic flushing rate or dilution rate = 1/hydraulic residence time in yrs.

Total ann P loading (kg)	Wall Lake Area (sq. M)	areal loading (g/sq-m)	Mean Depth	Dilution Rate	Predicted Phos. (mg/l)
406.34	570607.26	0.71	3.52	0.28	0.065

Table 3.5-6 Calculation of Predicted In-lake Phosphorus for Wall Lake

The model predicts a phosphorus concentration of .065 milligrams per liter for Wall Lake. Wall Lakes 2005 surface phosphorus concentration was very small falling below lab detection limits. Taking the hypolimnetic phosphorus level of .14 mg/l and dividing by two to arrive at a mean phosphorus concentration produces a concentration of .07 mg/l. This is relatively close to predicted. A slightly higher than predicted phosphorus level could be attributed to a number of possible causes. Low hypolimnetic oxygen levels could have resulted in a slightly higher than normal amount of internal loading in Wall Lake. While reductions in any of the major watershed sources of phosphorus can help water quality, it's particularly worthy to note that elimination of the estimated annual lakeside septic phosphorus load of 159 kg reduces the predicted in-lake phosphorus level to .039 mg/l. A change of this magnitude can have a visible effect on water quality.

3.6 Lake Sampling in 2005

Sampling of Wall Lake waters for this study included Secchi measurement (water clarity), temperature and oxygen profiles and conductivity and pH profiles. Also one sample each from the epilimnion and hypolimnion of Wall Lake were collected on August 24th and analyzed for the nine chemical parameters below and E-coli bacteria concentration.

Report of Analysis

Parameter	Method Code	MDL		Result	Units
Ammonia	EPA 350.3	0.01		0.02	mg/L
Nitrate	EPA 300.0	0.01	<	0.01	mg/L
Nitrite	EPA 300.0	0.01	<	0.01	mg/L
Ortho Phosphorus	EPA 365.1	0.007	<	0.007	mg/L
Phosphorus Dissolved	EPA 365.1	0.007	<	0.007	mg/L
Specific Conductivity	EPA 120.1	1		341	µS/cm@25C
Total Kjeldahl Nitrogen	EPA 351.3	0.08		2.16	mg/L
Total Phosphorus	EPA 365.1	0.007	<	0.007	mg/L
Turbidity	EPA 180.1	0.1		1.70	NTU

Table 3.6-1 Edglo Laboratories Wall Lake 8/24/05 Epilimnion (surface) Water Sample Analysis Results

Report of Analysis

Parameter	Method Code	MDL		Result	Units
Ammonia	EPA 350.3	0.01		0.54	mg/L
Nitrate	EPA 300.0	0.01	<	0.01	mg/L
Nitrite	EPA 300.0	0.01	<	0.01	mg/L
Ortho Phosphorus	EPA 365.1	0.007		0.011	mg/L
Phosphorus Dissolved	EPA 365.1	0.007		0.21	mg/L
Specific Conductivity	EPA 120.1	1		419	µS/cm@25C
Total Kjeldahl Nitrogen	EPA 351.3	0.08		3.28	mg/L
Total Phosphorus	EPA 365.1	0.007		0.145	mg/L
Turbidity	EPA 180.1	1		61.5	NTU

Table 3.6-2 Edglo Laboratories Wall Lake 8/24/05 Hypolimnion (bottom) Water Sample Analysis Results

Measured parameters from the epilimnion and hypolimnion of Wall Lake showed a typical distribution and magnitude of nitrogen and phosphorus containing compounds for Indiana lakes. Higher concentrations were present near the lake bottom where a summer accumulation of decomposing detritus occurs. Very low total phosphorus measurements at the surface contrasted sharply with .145 ppm total phosphorus in the hypolimnion. This may be due to very low rainfall runoff during the 2005 growing season coupled with some internal phosphorus loading from Wall Lake's sediments.

Report of Analysis

Parameter	Method Code	MDL		Result	Units
Ecoli	600-A-85-076	1	<	1	CFU/100ml

Table 3.6-3 Edglo Laboratories Wall Lake 8/24/05 Epilimnion (surface) Water Sample E-coli Analysis Results

Report of Analysis

Parameter	Method Code	MDL	Result	Units
Ecoli	600-A-85-076	1	15	CFU/100ml

Table 3.6-4 Edglo Laboratories Wall Lake 8/24/05 Hypolimnion (bottom) Water Sample E-coli Analysis Results

Measurements for E-coli bacteria were made from epilimnion (surface), and hypolimnion (bottom) samples collected near the center of Wall's larger basin. E-coli bacteria can be an indicator of the possible presence of pathogens from animal or human waste. Wall Lake's measurements were well below typical guidelines for safe swimming waters. Wall Lake's county beach should be checked separately during each season for possible contamination as E-coli levels in various areas of the lake can vary greatly.

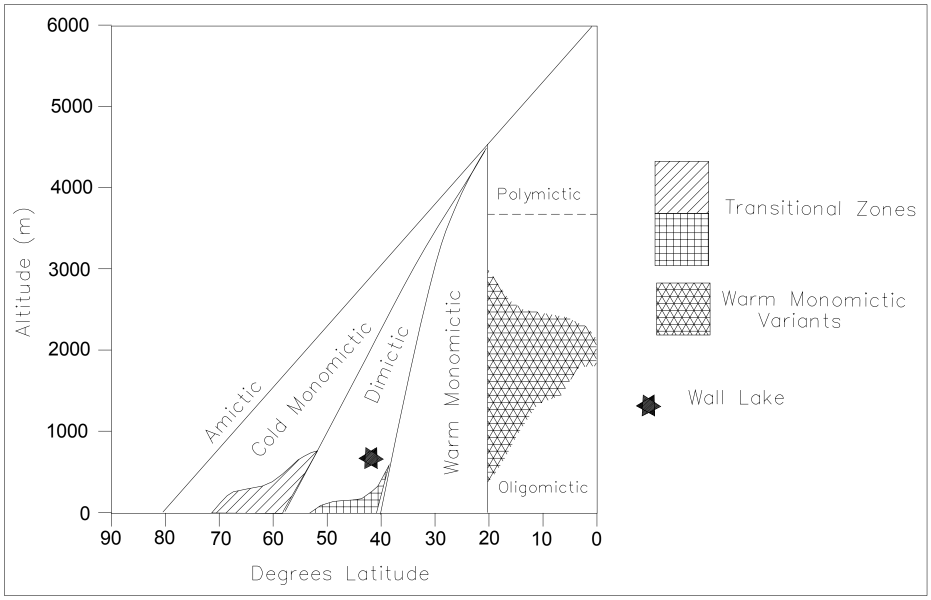
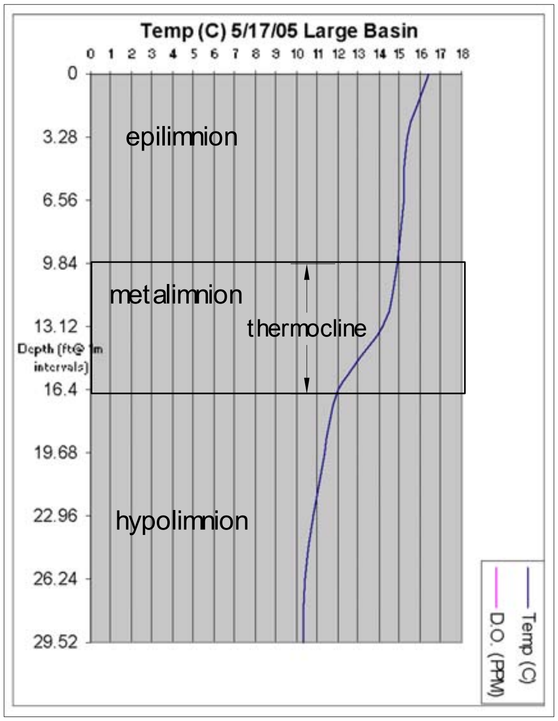


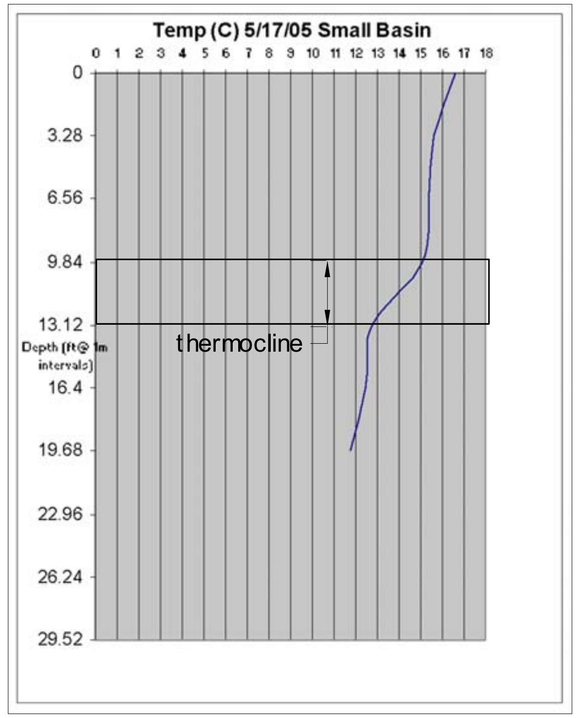
Figure 3.6-1 Lake Mixing Regime by latitude/altitude (Modified from Hutchinson etal 1956)

Lake seasonal stratification and mixing varies with latitude and altitude. At a latitude of 41° North and 850 feet above sea level, northern Indiana lakes tend to be dimictic (mix twice annually). Stratification occurs during the warm season as layers of the water column separate according to their temperature and corresponding densities. Fresh waters achieve maximum density at a temperature of 39° F with densities decreasing with a drop or rise in temperature from that point. In waters colder than 39°F the molecular crystal lattice structure of ice begins to form, with frozen waters having the lowest density. As the atmosphere and solar radiation warm lake waters in the spring three distinct layers form in the water column. The epilimnion occupies the warmest, upper portion of the lake waters. The metalimnion or "thermocline", (the middle portion), is a transitional zone of rapidly declining temperature gradient. The hypolimnion is the deepest and coolest portion of the water column. Mixing of water between the three layers is limited during the summer due to the contrasting densities. When the epilimnion starts to cool in the fall its waters drop vertically, effectively breaking the density barriers between the strata. This is referred to as "Fall turnover." At this time of year, nutrients that have built up in the hypolimnion as a result of accumulated detritus, are free to mix throughout the water column. This is one reason that a nutrient spike or "autumnal release" of phosphorus may be noted in the fall. Winter stratification is thermally inverted, with the densest (39° F) waters on the lake bottom and the coldest (32° ice) on top. At some point in the spring, surface waters warm to near 39° F and the full height of the water column achieves near-uniform density. At that point, wind and wave action can effectively mix lake waters. This is termed "spring mixing." The dimictic glacial lakes of Indiana normally experience spring and fall mixing throughout the entire water column making them *holomictic*.

Temperature profiles were taken at Wall Lake on May 17th, 2005 in both the large and small lake basins.(see graphs 3.6-1 and 3.6-2) Spring mixing was complete and stratification had begun. Wall Lake displayed a normal clinograde (declining) temperature profile in both basins.

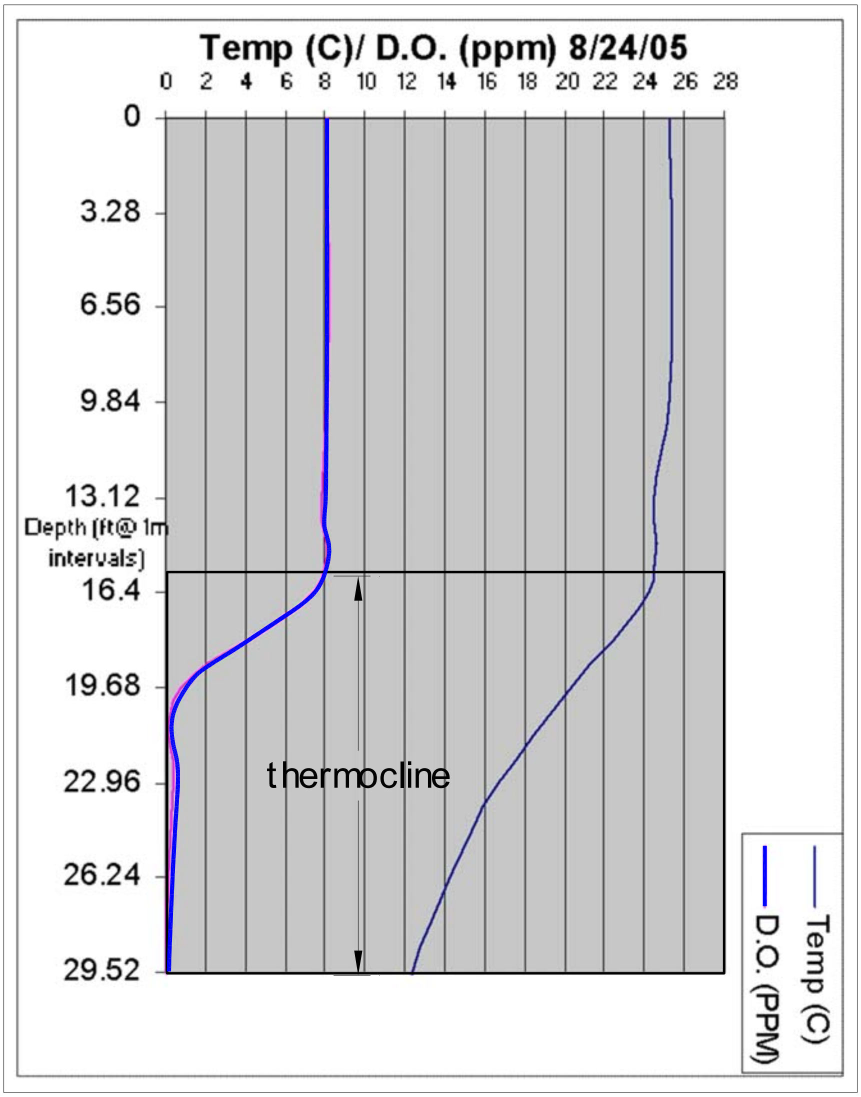


Graph 3.6-1 5/17/05 Temp. Profile for Wall's Large Basin

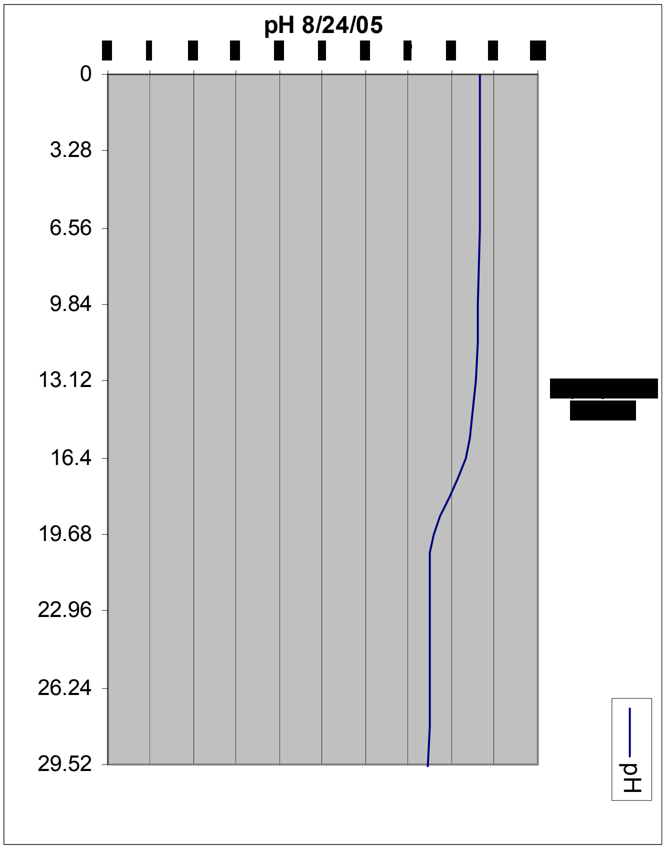


Graph 3.6-2 5/17/05 Temp. Profile for Wall's Small Basin

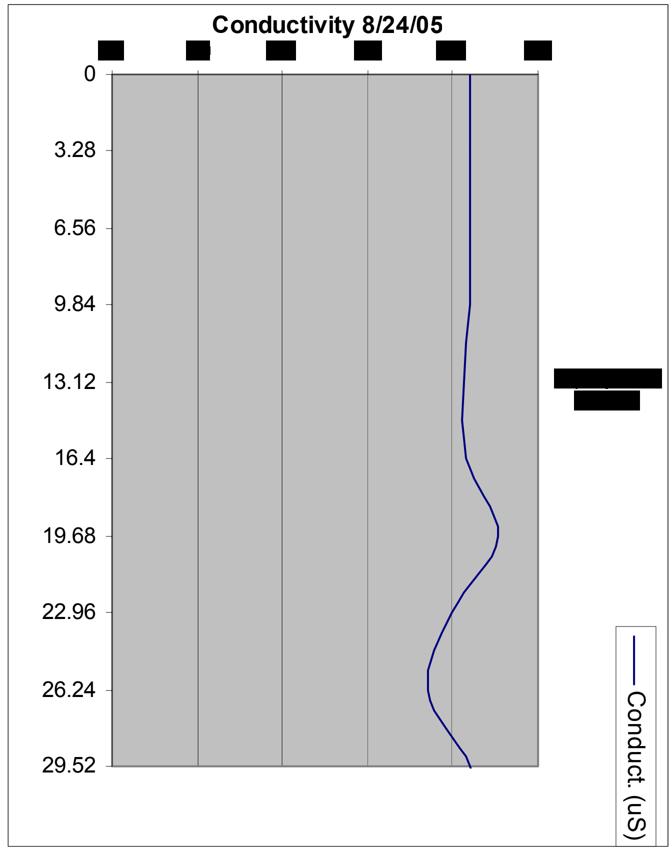
The thermocline (the area of the water column with a rapid temperature gradient), was developing at a depth of approximately three meters. This profile will be important to consider in future "whole lake" fluridone treatments for Eurasian watermilfoil. Pre-planning of initial dosages can be based on the majority of pesticide staying within the volume of the upper portion of the water column (epilimnion) in Wall Lake. Final dosing should be based on a same-day check of the profile. Both temperature and oxygen profiles were taken on August 24th of 2005. (see graph 3.6-3) Dissolved oxygen levels in Wall Lake were high enough to sustain sportfish down to a depth of approximately 5.5 meters (18 feet). Clinograde oxygen profiles near the thermocline and below are common in lakes like Wall. This occurs as planktonic organisms in the lake complete their life cycle and die, losing buoyancy and motility and sinking into the hypolimnion where they decompose. Aerobic (oxygen utilizing) Bacteria in the hypolimnion deplete summer oxygen levels as the season progresses. This effect seems to have increased slightly since 1992 as Wall Lake has displayed a larger percentage of anoxia (oxygen free conditions) in its water column. Higher total phosphorus levels in the hypolimnion also suggest an increase in this process. Phosphorus can become concentrated in the hypolimnion as planktonic detritus (dead material) and its associated nutrients accumulate. Minimizing nutrient loads to the lake can increase the amount of habitat and range of thermal conditions available to Sportfish during the summer months by decreasing this effect. Minimizing water column anoxia can also help water quality by decreasing internal nutrient loading. Anoxic conditions at the sediment-water interface generally lead to a higher exchange of accumulated sedimentary phosphorus with the water column. High oxygen levels at the sediment-water interface typically lead to the creation of iron-oxides which have a high affinity for phosphorus and act to rebind and resettle nutrients keeping them out of the upper strata where they spur planktonic algae growth and affect water clarity.



Graph 3.6-3 Temperature and Oxygen Profiles for Wall Lake 8/24/05



Graph 3.6-4 8/24/05 pH profile for Wall Lake



Graph 3.6-5 8/24/05 Conductivity profile for Wall Lake

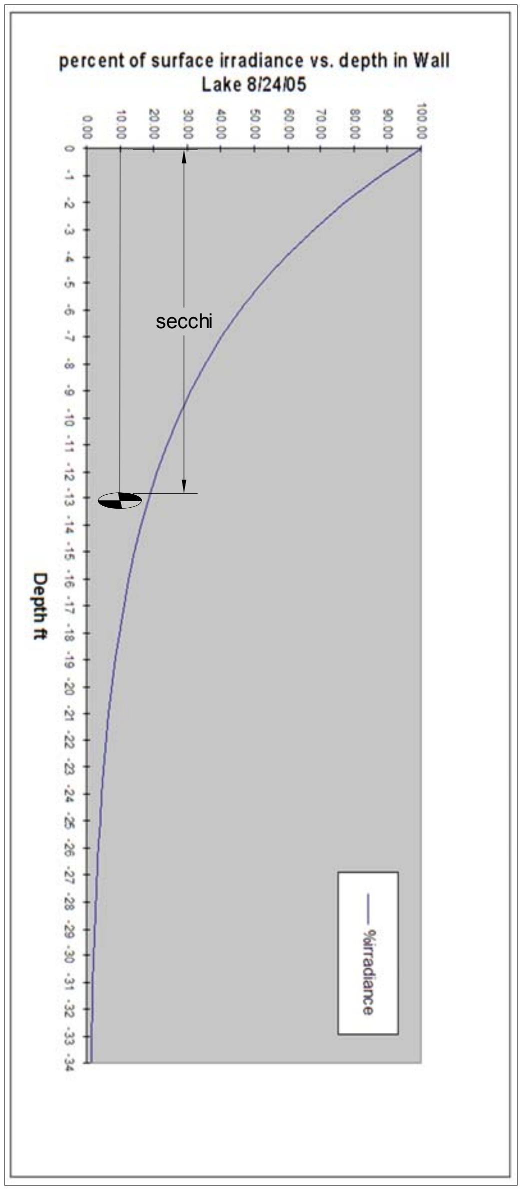
Conductivity and pH profiles were recorded for Wall Lake on August 24th, 2005 (graphs 3.6-4 and 3.6-5). pH is defined as the negative log of the water's hydrogen ion concentration. Wall Lake's pH was basic near the surface declining to near neutral (7) at the bottom. Higher pH levels in lake surface waters is common in Indiana Lakes, resulting from photosynthetic plants and algae chemically interacting with water column carbonates during the growing season. High amounts of carbonates, calcium and their chemical variants occur in most northern Indiana lakes and are collectively known as the carbonate-bicarbonate buffer system. These substances enter the system as solutes in ground-water and runoff that enters the lakes. During the warm season these substances interact according to the following equation:

←← DISSOLUTION ←←

$$Ca(HCO_3)_2 \leftrightarrow CaCO_3 \downarrow + H_2O + CO_2$$

→→ PRECIPITATION →→

As photosynthetic organisms (planktonic algae and macrophytes) pull Carbon Dioxide from the water column, the equation is driven in the precipitation direction to reestablish equilibrium. This ties up free hydrogen ions in water molecules correspondingly increasing the pH of the water. Calcium carbonate ($CaCO_3$) falls from the water column as a precipitate, often chemically binding with phosphorus, committing it to the sediments. This calcareous sedimentation gives some Indiana lake bottoms a light color, encrusting many rooted aquatic plants and providing a continual scrubbing effect, moderating phosphorus levels. At times of low photosynthetic activity, bacterial decomposition, will shift the equilibrium of the equation toward dissolution. This occurs in the lower strata of the lake (hypolimnion) as respiration by bacterial decomposition boosts Carbon Dioxide levels driving the equation in the opposite direction and lowering pH. Particulate marl settling downward in the water column is often resolubilized in the hypolimnion leaving its nutrient load isolated from opportunistic alga in the shallower photic zone. Wall Lake displayed a normal conductivity profile with some stratified variation in conductivity. Conductivity measures the content of ions in lake water that contribute to electrical conductance.



Graph 3.6-6 8/24/05 Wall Lake Irradiance Profile

With an 8/24/05 Secchi disk measurement of 4 meters (13.1 feet) water clarity was good at Wall Lake in 2005. This was better clarity than most seasons. Secchi measurements in Wall Lake were 2.9 meters, 3.9 meters, and 3.1 meters in 1997, 1992, and 1989 respectively.

4. Wall Lake Watershed Characteristics

Land use and cover on lands draining to a lake are often the largest influence on the water quality of the lake. Agricultural lands and construction sites often produce nutrient rich soil runoff during times when plant cover and root systems are not present to stabilize soils during runoff events. Fertilization and crop residues on agricultural lands can contribute dissolved nutrients in rain and snow melt runoff. Developed areas can contribute nutrient rich runoff if lawn fertilizers are used. Forest, scrub, and other well vegetated areas often contribute very little to lake nutrient loads because of the protective effect of the plants present. For this work USGS topographic elevation data was used to delineate the Wall Lake's 753 acre watershed. USGS satellite photos were used to create a CAD (computer aided drawing) drawing of the Wall Lake watershed delineating general land use and land cover (see map 4-1). Wall Lake's watershed is largely used for agriculture (54%), but also contains significant woodland areas (11%), wetland areas (9%) and developed lands (8%).

Land Use/Land Cover Type	Acres	Percent of Watershed
Developed Lands	59	8%
Wooded	81	11%
Wetlands	69	9%
Agricultural (adjusted)	403	54%
Water	141	19%
Total Watershed Area	753	100%

Table 4-1 Land use and land cover in the Wall Lake watershed

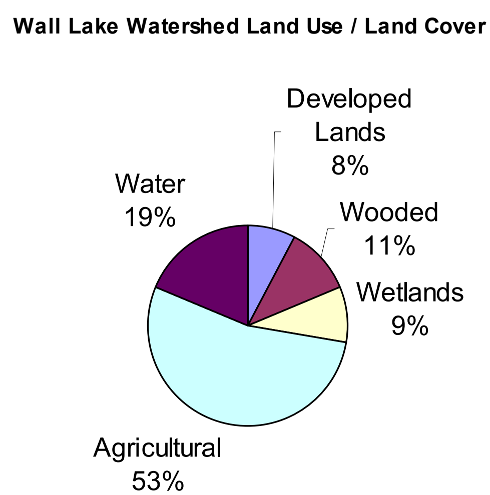
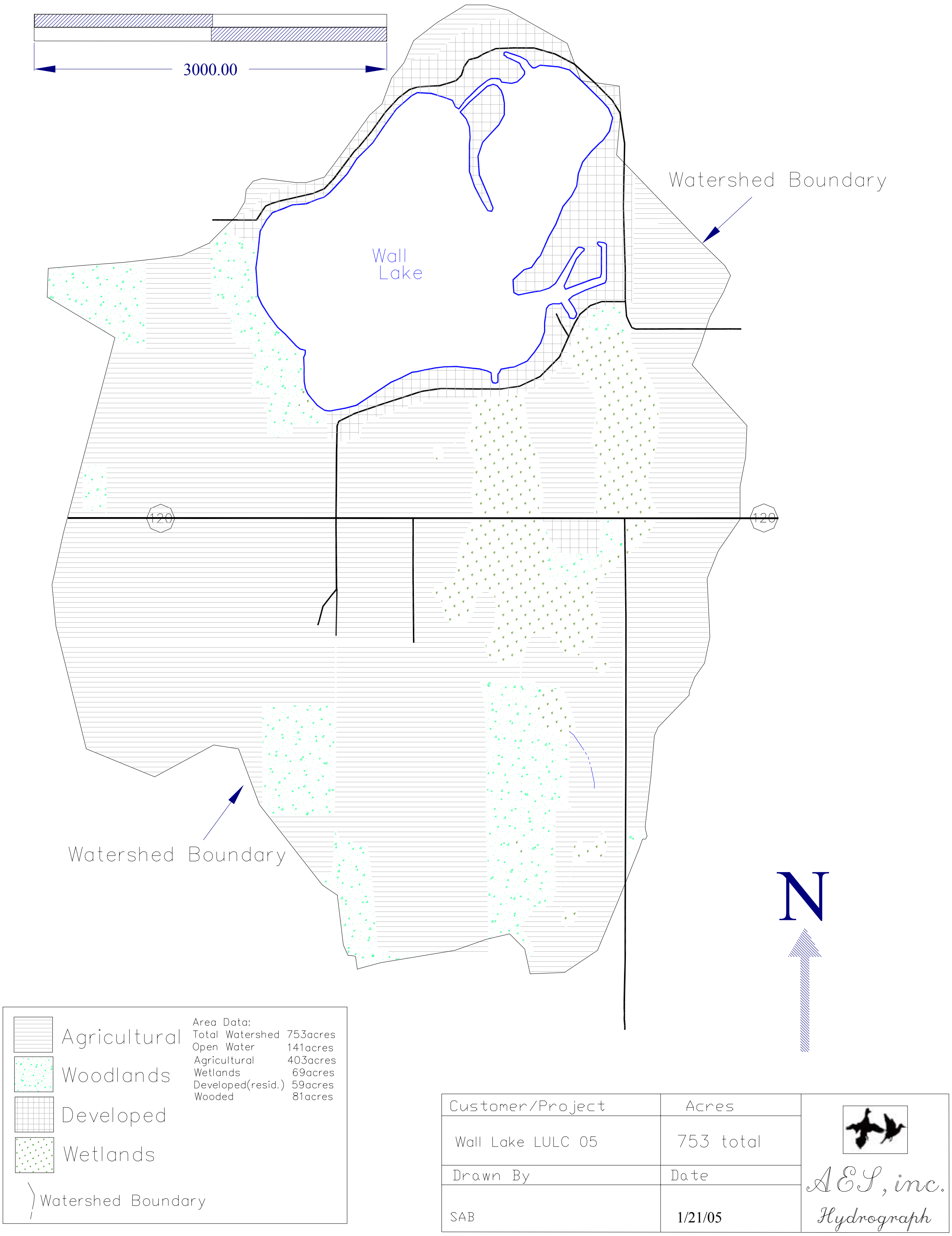


Figure 4-1 Pie Graph, Land use / land cover in the Wall Lake Watershed



Map 4-1 Land use / land cover in the Wall Lake Watershed

4.1 The Wall Lake Tributaries

Wall Lake is fed by two small intermittent tributaries which drain two wetland systems and surrounding farm fields. The tributaries both drain lands south of the lake, running south to north crossing under County Road 565 North through small culverts before entering the lake. (see map 4.1-1) Both of these tributaries are original drainages, but have been somewhat ditched/channelized in the past in an attempt to facilitate wetland drainage. Much of the function of this ditching appears to have been lost in these areas and the hydrology of these corridors is very wet. Ponding and flooded emergent wetlands are present in the Southwest tributary drainage. These wetlands probably contribute a significant filtering effect to runoff draining through these areas. Protection and enhancement of these areas will be a recommendation of this report.

Table 4.1-1 Storm flow sampling 7/16/05 laboratory sample results

Parameter	Total Phosphorus (ppm)	Orthophos. (ppm)	Ammonia (ppm)	Nitrate+Nitrite (ppm)	Specific Cond.(uS/cm@25C)	TKN (ppm)	Turb. (NTU)	E-coli (CFU/100ml)
East Tributary	.471	.242	.14	.48	166	.96	26.5	no data
West Tributary	.287	.142	.19	.26	308	1.6	19.1	no data
St. Joseph River Watershed Mean IDEM 2000-2005 stream data	.382	No data	1.19	3.52	764.19	2.28	17.41	1895.58

Table 4.1-2 Storm flow sampling 7/16/05 field measurement results

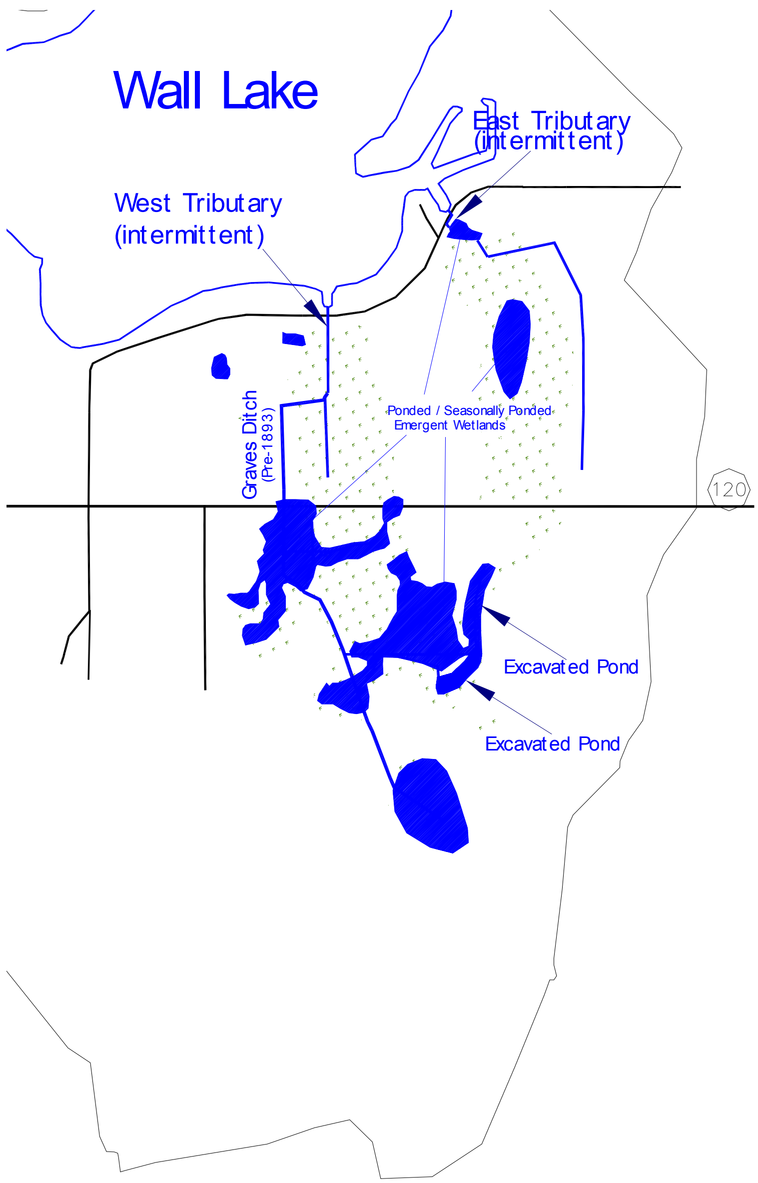
Parameter	D.O. (ppm)	Temp (C)	pH	Conductivity (uS)	Specific Cond.(mv)	Salinity (ppt)	Est. Flow Rate (CFM)	Notes
East Tributary	6.32	22.7	7.57	151.8	-53mv	.1	1.9	
West Tributary	5.68	22.0	7.14	277.3	-28mv	.1	42.34	
St. Joseph River Watershed Mean IDEM 2000-2005 stream data	7.14	19.91	No data	764.19	No data	No data	-	

Table 4.1-3 Baseline flow sampling 8/17/05 laboratory sample results

Parameter	Total Phosporus (ppm)	Orthophos. (ppm)	Ammonia (ppm)	Nitrate+Nitrite (ppm)	Specific Cond.(uS/cm@25C)	TKN (ppm)	Turb. (NTU)	E-coli (CFU/100ml)
East Tributary	.013	<.007	.12	<.01	644	1.60	933	357
West Tributary	1.39	.226	.22	<.01	740	3.2	2.50	480
St. Joseph River Watershed Mean IDEM 2000-2005 stream data	.382	No data	1.19	3.52	764.19	2.28	17.41	1895.58

Table 4.1-4 Baseline flow sampling 8/17/05 field measurement results

Parameter	D.O. (ppm)	Temp (C)	pH	Conductivity (uS)	Specific Cond.(uS)	Salinity (ppt)	Est. Flow Rate (CFM)	Notes
East Tributary	6.08	23.6	7.79	666	683	.63	.01	
West Tributary	.43	23.1	7.21	553	573	.30	.18	Lots of Organic material
St. Joseph River Watershed Mean IDEM 2000-2005 stream data	7.14	19.91	No data	764.19	764.19	No data	-	



Map 4.1-1, Wall Lake Tributary Drainages

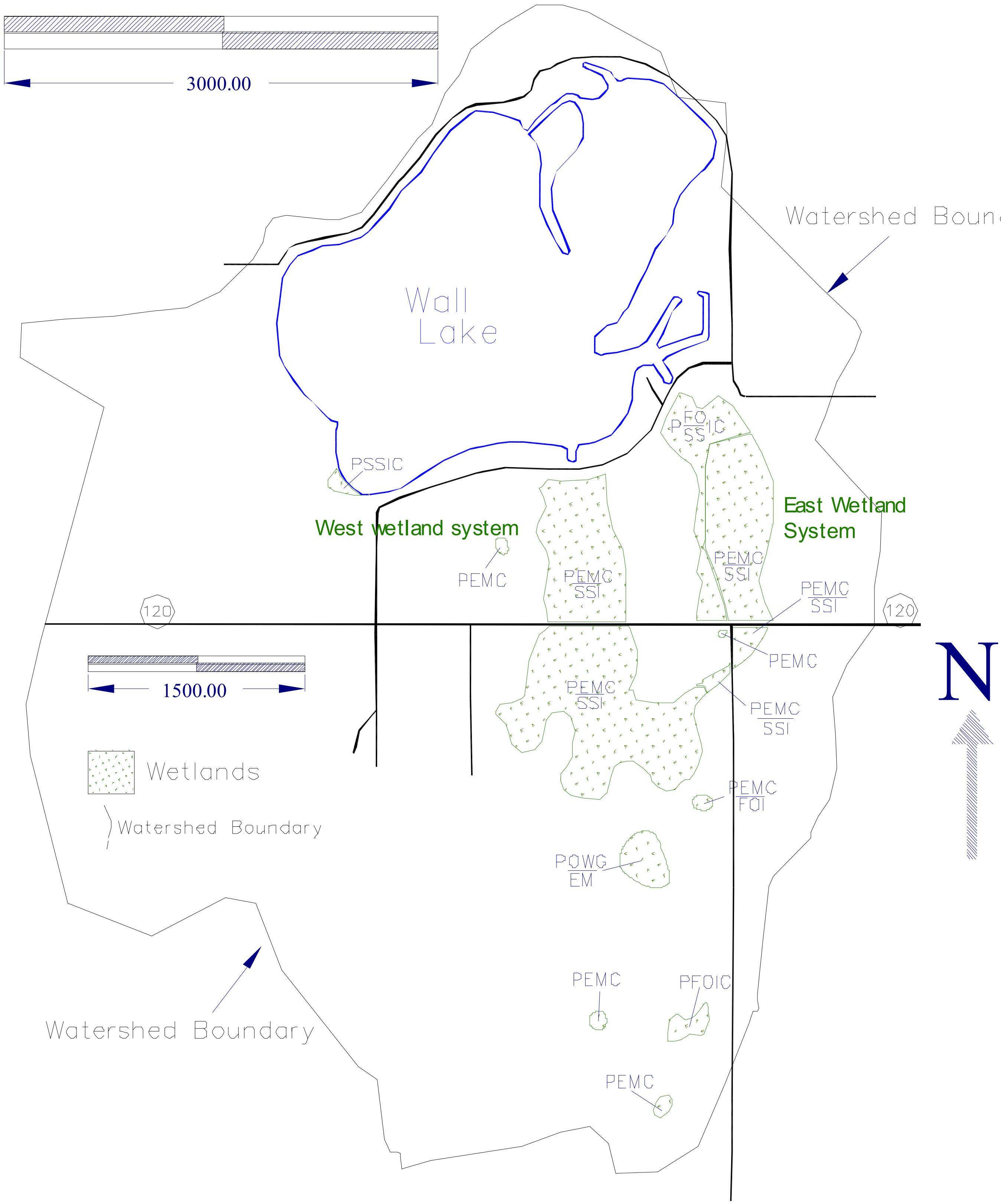
Droughty conditions in the spring of 2005 made sampling of Wall Lake's tributaries difficult. The Wall Lake tributaries are very small and rain events throughout the 2005 season repeatedly failed to produce sufficient flow for sample collection. Finally after a July 16th storm event flows were sufficient for the collection of water chemistry samples. Approximately 1 inch of rainfall fell in two hours with a peak rate of .89 inches per hour. (Northwood subdivision weather station Angola, IN, Weather Underground, Ann Arbor, MI) Due to laboratory time constraints E-coli samples could not be analyzed from this event.

In collected rain-event samples both tributaries showed significant phosphorus content (data in table 4.1-1 above) with .471 ppm and .287 ppm for the east and west tributaries respectively. The east was above the average of .382 ppm for randomly collected probabilistic stream data provided by the Indiana Department of Environmental Management from 2000 and 2005 (125 samples from the St. Joseph River drainage). While IDEM probabilistic data is provided in the tables for comparison it should be noted that the small size and intermittent flow regime of the Wall Lake tributaries differs greatly from most of the streams included in the IDEM probabilistic and other stream water quality data sets. This should be considered in making the comparison. Approximately half of the phosphorus content of the tributary waters was in the form of orthophosphorus. Orthophosphorus is the form of this nutrient that can most quickly be utilized for algal growth in aquatic systems. Rain-event nitrogen parameters were well below the IDEM probabilistic data set with .14 and .19 ppm ammonia (1.19 ppm IDEM) and .48 and .26 ppm nitrate+nitrite collected from the east and west respectively (3.52 ppm IDEM). Flow rates in the two tributaries were low at 1.9 and 42.34 CFM (cubic feet per minute) respectively, so an obvious problem with nutrient loading was not apparent. The significant phosphorus measurements probably resulted from the droughty conditions in 2005. This was probably the first flush of accumulated nutrients and decomposing organic materials from these watershed areas in a considerable period of time. At a flow rate of 42.34 CFM (cubic feet per minute) the West Tributary was seen to carry considerably more water than the east tributary after this rain event. Dissolved oxygen levels were 6.32 ppm and 5.68 ppm for the east and west respectively. This was lower than the IDEM dataset average of 7.14 ppm, but was still high enough to support most fish and benthic macroinvertebrate life.

On August 17th both tributaries had developed enough flow to be able to collect baseline samples. (See tables 4.1-3 and 4.1-4) Phosphorus related parameters were surprisingly low in the East Tributary (.013 ppm) but much higher in the West (1.39 ppm). This did not amount to a significant loading on Wall Lake because of the miniscule flow rates at this time (.01 and .18 CFM on the East and West respectively). Dissolved oxygen levels were 6.08 ppm in the east tributary, slightly below the IDEM dataset average of 7.14 ppm. In the west tributary dissolved oxygen was unusually low at .43 ppm. A large amount of suspended decomposing organic material was noted in the west flow and this may have contributed to the low oxygen condition. Baseline flow nitrogen related parameters were relatively low in the tributaries with .12 ppm and .22 ppm ammonia measured in samples from the east and west tributaries respectively. This was well below the IDEM dataset average of 1.19 ppm. Nitrate+nitrite measurements for both streams were below the lab detection limit of .01 ppm. An excessively high turbidity measurement of 933 NTU (Nephelometric Turbidity Units) was produced by the baseline sample from the west tributary. A high amount of organic material present in the west tributary flow may have possibly contributed to this measurement. It is not certain whether some portion of this extreme number may also be attributable to experimental error.

E-coli standards for primary-contact recreational waters (where uses such as swimming are permissible) vary among public agencies. The bacterial water quality standard for full body contact recreation in Indiana is based on E.coli, as recommended by the EPA. The geometric mean of 5 samples over a 30-day period is required to be less than 125 CFU/100 mL, with no sample testing higher than 235 CFU/100 mL. Monitoring results for E. coli are usually given in terms of number of E. coli colony forming units (or CFU) in 100 mL of water. Bearing this in mind, both tributaries were relatively high in E-coli at 357 and 480 CFU on the east and west respectively. Both these samples were still well below the mean E-coli count from the probabilistic data set from other Indiana Streams of 1895.58 (MPN). Obviously many streams in the probabilistic data have very elevated E-coli levels. Lacking any apparent source of human or animal waste in these drainage areas the Wall Lake measurements may be the result of natural baseline E-coli levels. While the stream flow rates were very low in 2005 the potential still might exist for an E-coli problem in the lake waters near the stream inlets. Periodic summer testing of lake waters near these steams for E-coli may be wise to insure suitability for swimming.

A large amount of accumulated organic matter decomposing in the wetlands coupled with very low flow conditions may have contributed to the relatively low oxygen levels measured in the streams. Part of the chemical differences between the tributaries may be attributable to a lack of ponded areas in the west tributary's corridor. Two ponded emergent wetland areas in the east drainage contain submersed aquatic plantbeds that probably help oxygenate passing waters. One of these areas is immediately upstream of Wall Lake so nearly all of the drainage in this tributary passes through this small ponded wetland area. Submersed macrophytes and algae in ponded areas also help to induce marl precipitation that can help scrub phosphorus from passing waters. The Wall Lake residents may want to consider modifying the hydrology and vegetation in the west tributary's marshy corridor to take advantage of the type of positive effects ponded areas appear to have on East tributary water quality. Examining options for possible habitat management within both these wetland areas and their adjacent agricultural areas will be a recommendation of this report. Reed canary grass (*Philaris arundenacia*) an Invasive disturbance-oriented species was present in the wetlands and much of the wetland areas are dominated by woody shrubs. A management regime that favors native sedges and wet grasses to enhance habitat, phosphorus removal, and soil stabilization may be an option that can optimize wetland function in both these areas. Flows in the Wall Lake tributaries were not sufficient in the 2005 season to allow collection and evaluation of benthic macroinvertebrates. Because the Wall Lake tributaries are very small and have intermittent flow they have probably not been sampled previously and no collected historical data was found for comparison.



Map 4.2-1 Wall Lake Watershed Wetlands

4.2 Wetlands

Wall Lake's watershed has retained some of its most valuable natural features with 69 acres of wetlands comprising nine percent of the total watershed area for the lake. More importantly, these wetlands serve as filtration basins for approximately one third of the lake's drainage area with the majority of this acreage agricultural. Water quality protection at Wall Lake will always involve wetland protection. The majority of the agricultural ground in the Southeast portion of the watershed drains to one of two wetland corridors through which Wall Lake's small tributaries run. These areas are a combination of forested, scrub-shrub, and emergent wetlands. Both of these wetland systems probably originally began in a marsh lying due south of Wall Lake on the south side of State Road 120. (see map 4.2-1 above) The southeast wetland system appears to have been disconnected from this origin by the construction of 120 and County Road 100 West, and now begins at 120. It runs north from 120 as a cattail marsh. The central portion of this marsh contains an open-water basin with bulrush and other native plants growing as emergents. (see photo 4.2-1 below) The property owner has placed a dock in

Photo 4.2-1 Central Portion of the Southeast Wetland System

this basin to provide recreational access. Wood duck nest boxes have been placed in the marsh. A gentle slope dividing the marsh from an agricultural field just west of the marsh is dominated by trees. The transitional zone between the tree line and marsh contains reed canary grass. This area has probably absorbed eroded sediment in the past from the field. This border may be a potential area where a filter strip could be helpful. North of the open water basin a transition to cattail marsh and then scrub shrub wetland occurs. Near its north third a transition to mixed wooded/scrub-shrub wetland occurs. Another flooding lies at the northern tip of this basin adjacent to County Road East 565 North. (photo 4.2-2 below) This flooding drains along 565 North before flowing through a culvert under

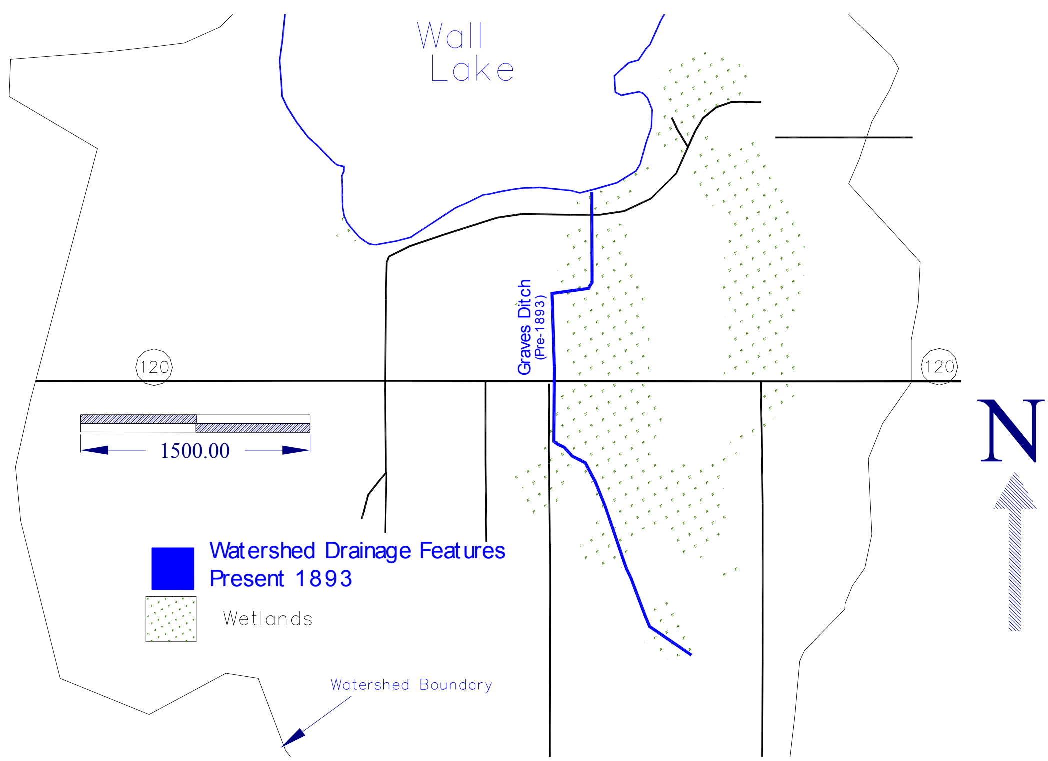
Photo 4.2-2 Flooding at the Northern End of the East Wetland System.

the road and entering Wall Lake's southeast channel system. This marsh appears to have originally terminated in a riparian wetland area contiguous with Wall Lake that was filled and dredged in the late 1950's to create the lake's southeast channel system. (see wetland loss map 4.2-6) A system of trails is maintained through this marsh to allow recreational access. Wall Lake's other marshy drainway begins south of U.S. 120 in an emergent scrub-shrub marsh that remains flooded in most seasons. This area contains two excavated ponds connected to the marsh. (see photo 4.2-3) This marsh and the lands adjacent to it are maintained exclusively as wildlife habitat. This system drains north toward Wall Lake via a concrete culvert under State Road 120. North of 120 the marsh is thickly covered with woody shrubs to its north end at East 565 North. A trail system is also maintained through this wetland to allow recreational access. A narrow corridor of cattails marks the remnants of Grave’s ditch (see photo 4.2-4) running centrally through the marsh terminating at Wall Lake near the public access.

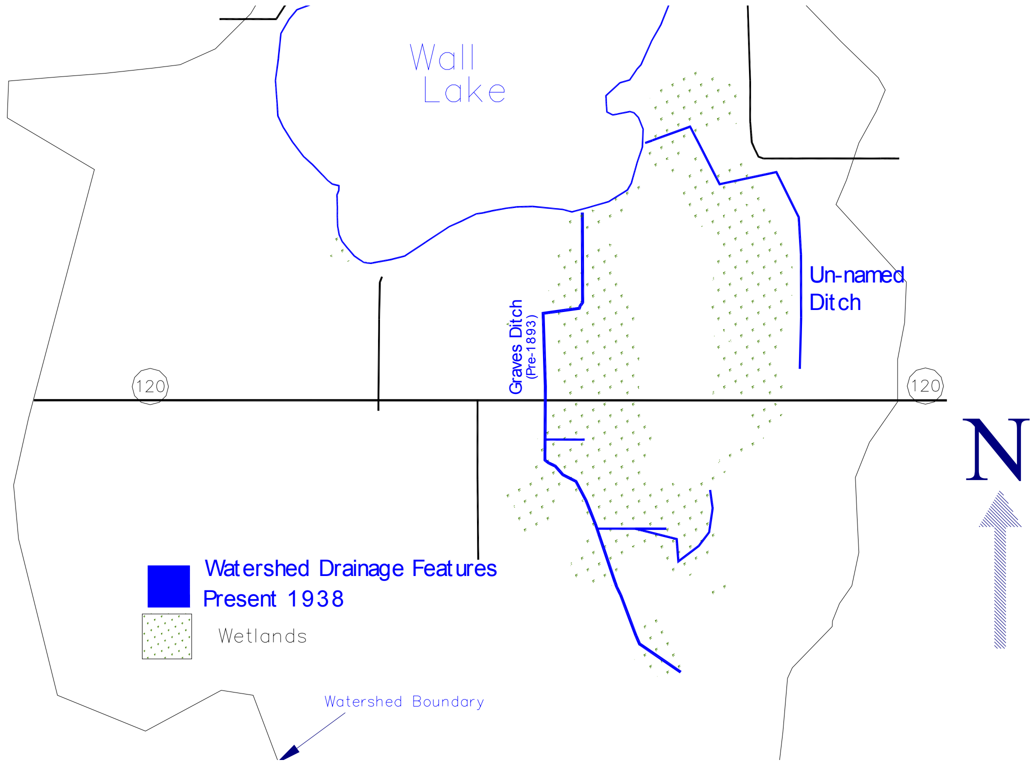
Photo 4.2-3 Excavated Ponds at the Headwaters of the Western Wetland System Draining to Wall Lake

Photo 4.2-4 Remnants of Ditching Through Wall Lakes West Wetland Corridor Shrub Swamp

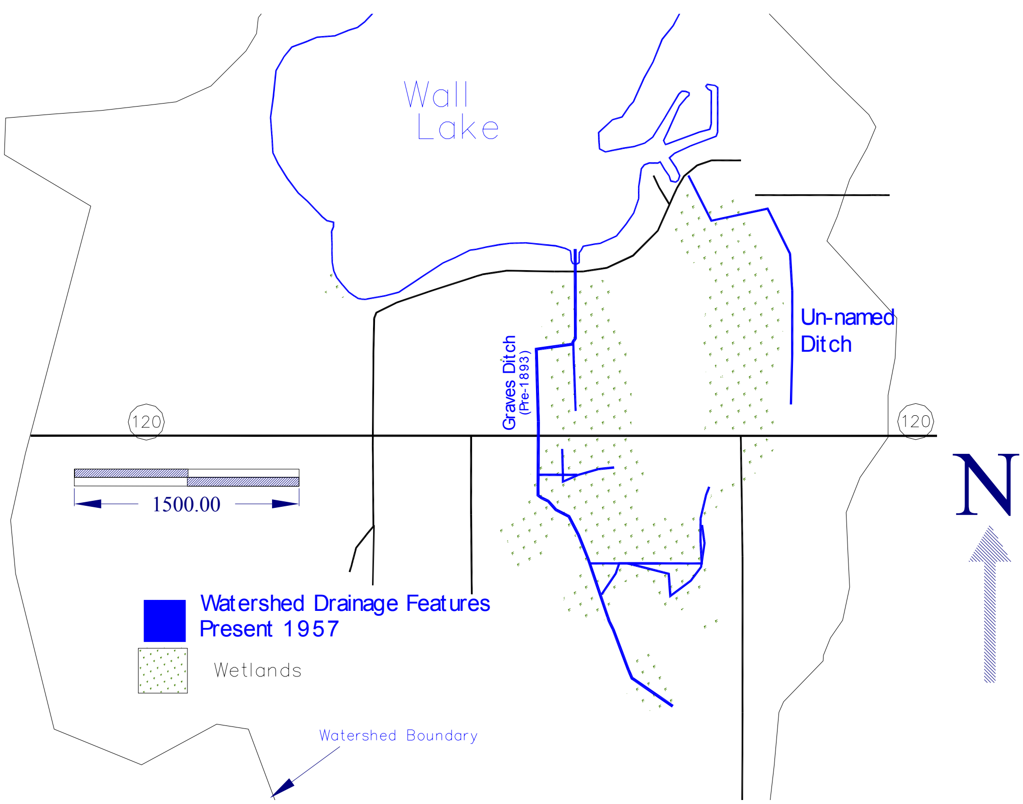
There have been significant attempts at drainage of Wall Lake's wetlands since settlement of the area began. (See maps pages 73-75) Attempts at drainage probably started with the excavation of Graves ditch running through the West wetland corridor draining to Wall Lake. Graves ditch appears on the 1893 plat book for the area. Much of this infrastructure has deteriorated or been defeated by beaver activity. The Wall Lake residents may wish to investigate the possibility of further defeating the remnants of this drainage to better restore the original hydrology, especially in the west wetland system. There also may be options for enhancing vegetative cover on the wetlands, especially with regard to restoring areas containing reed canary grass. Placing filter strips on key field borders could also help to reduce soil input to the wetlands. Working with landowners to seek long-term protection for these wetland areas will also be a recommendation of this report. Based on 1938 air photos, the Lagrange and Steuben County soil surveys, and Lagrange County water quality reports it appears that the Wall Lake watershed has lost at least 20 acres of wetlands. (see map 4.2-7 pg. 76) Most of these areas of loss have been developed. This includes the southeast channels, the two channel areas off of Wall Lake's small basin and the peninsula on the lake's north shore. Because these areas have been developed, wetland restoration efforts in the watershed should concentrate principally on enhancing existing wetlands. Based on the extent of Hydric (current and former wet) soils (map 4.2-7a pg 77) additional losses of smaller scattered wetlands may have also occurred on agricultural lands.



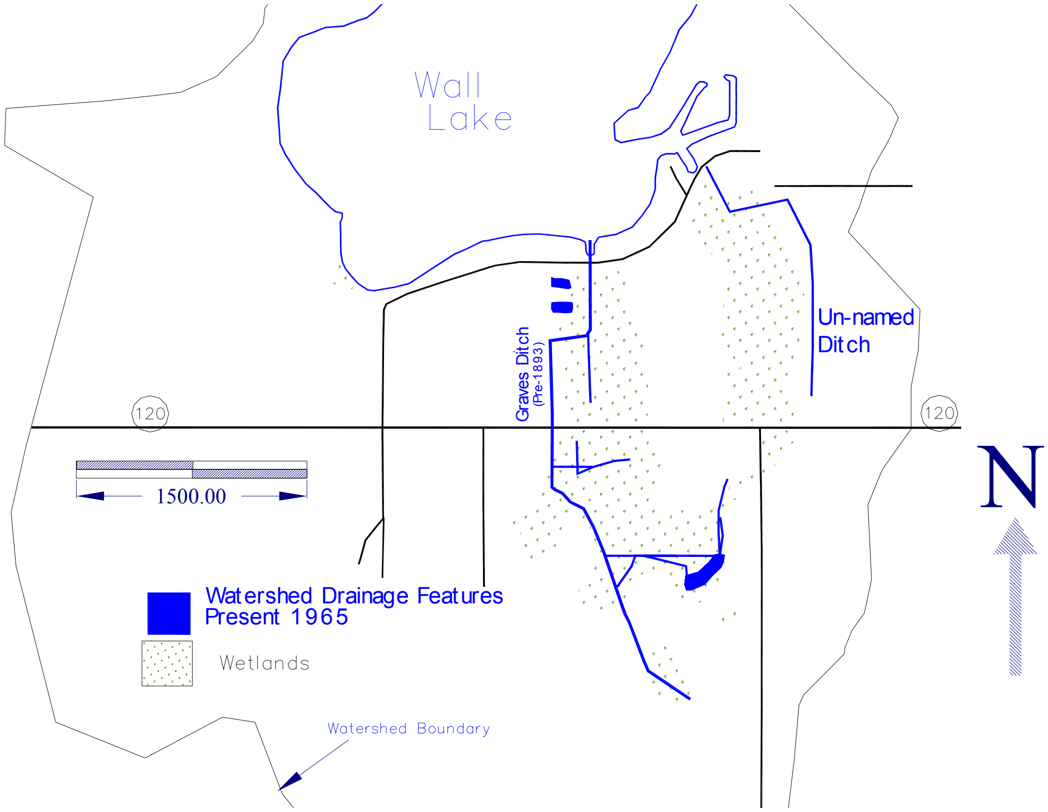
Map 4.2-2 Known Wall Lake Wetland Drainage Features 1893



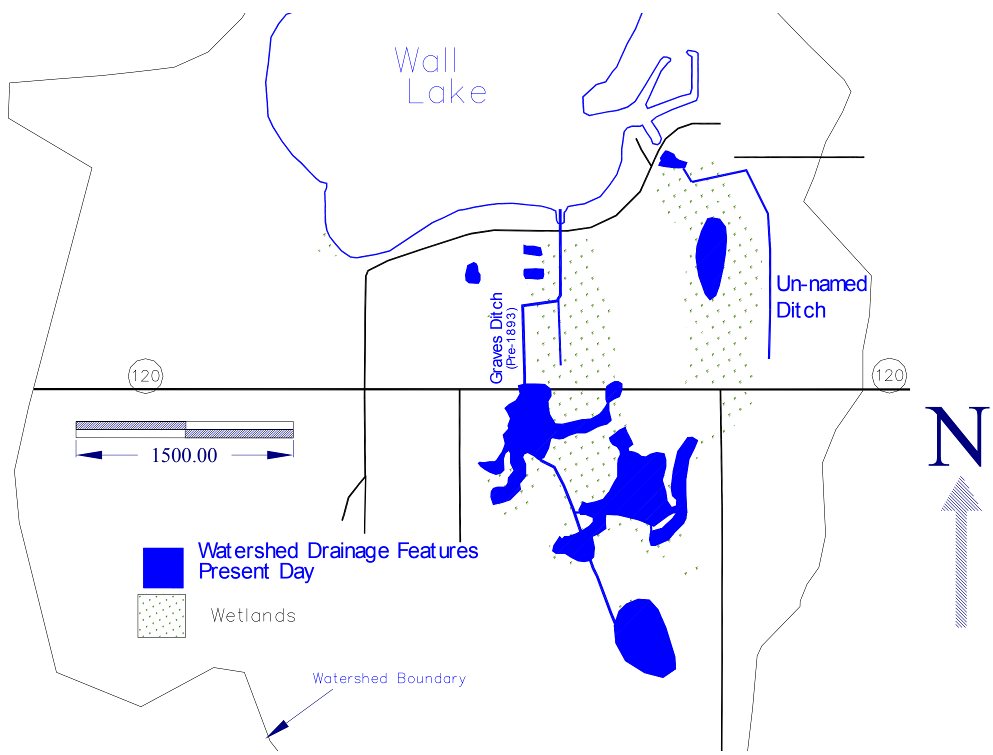
Map 4.2-3 Known Wall Lake Wetland Drainage Features 1938



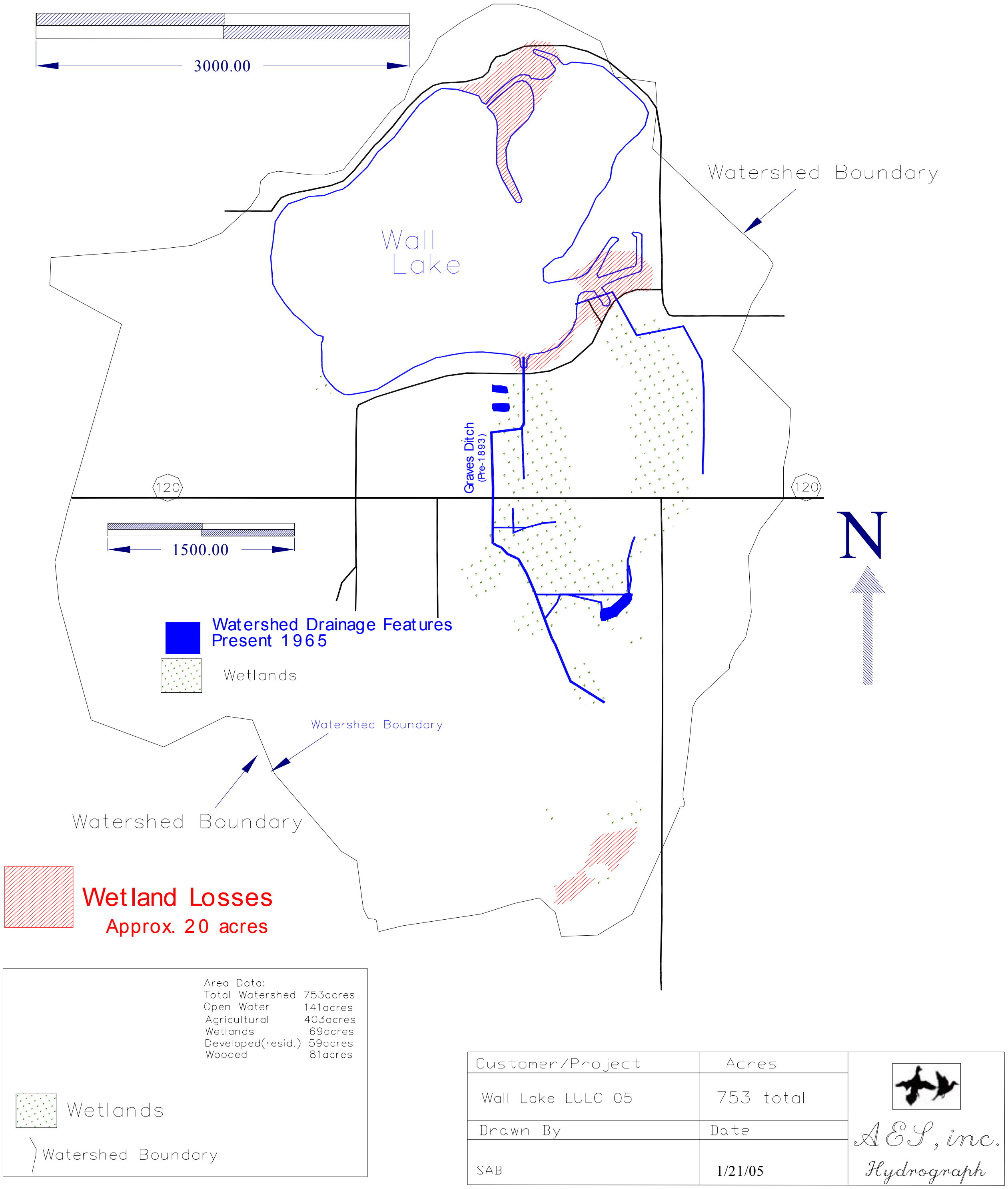
Map 4.2-4 Known Wall Lake Wetland Drainage Features 1938



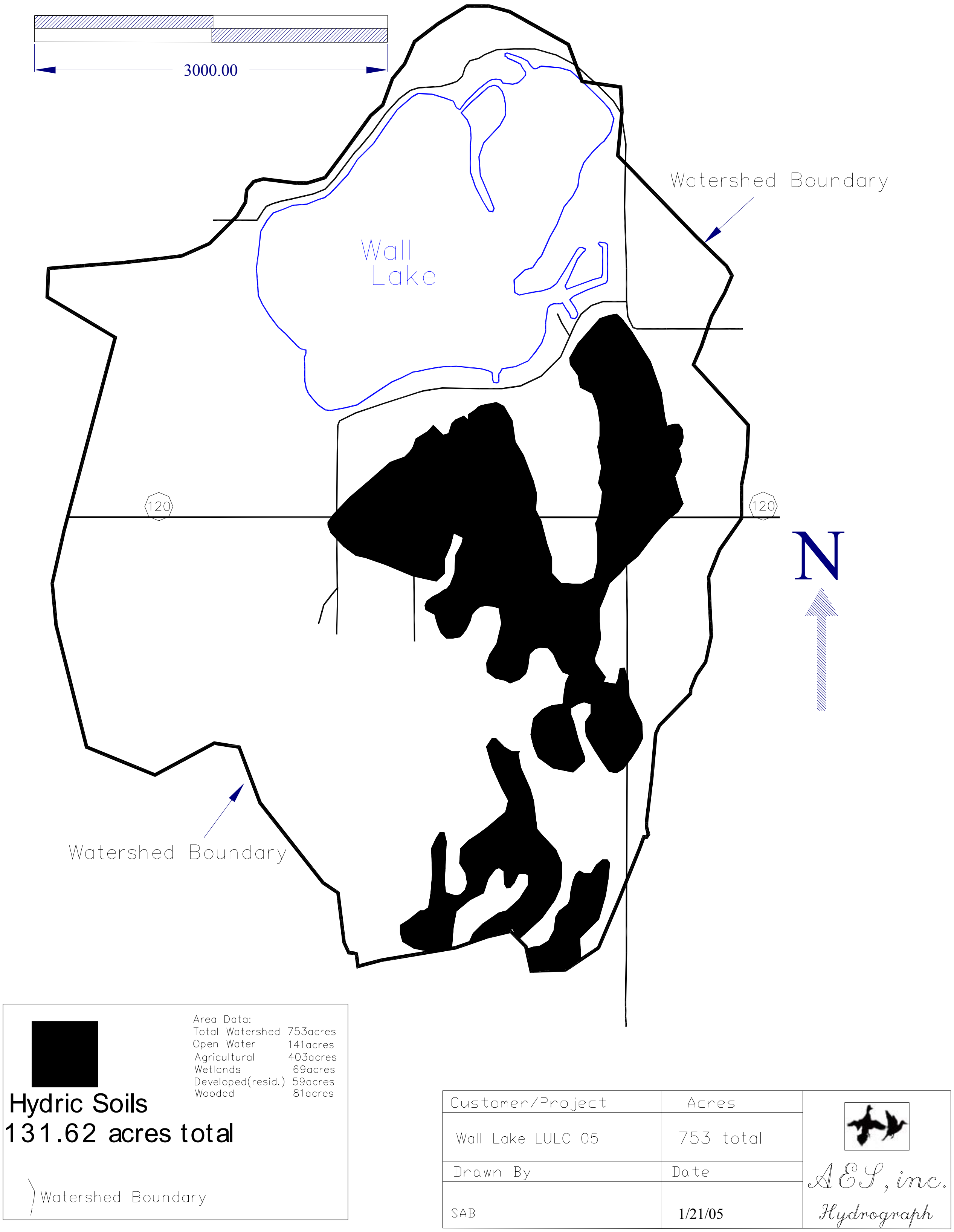
Map 4.2-5 Known Wall Lake Wetland Drainage Features 1965



Map 4.2-6 Known Wall Lake Wetland Drainage Features Present



Map 4.2-7 Wall Lake Wetland Losses



Map 4.2-7a Hydric Soil Units within the Wall Lake Watershed Indicate Current and Former Wet Areas


Photo 4.3-1 Single Purple Loosestrife Plant in a Native Wetland Adjacent to Wall Lake in 2005

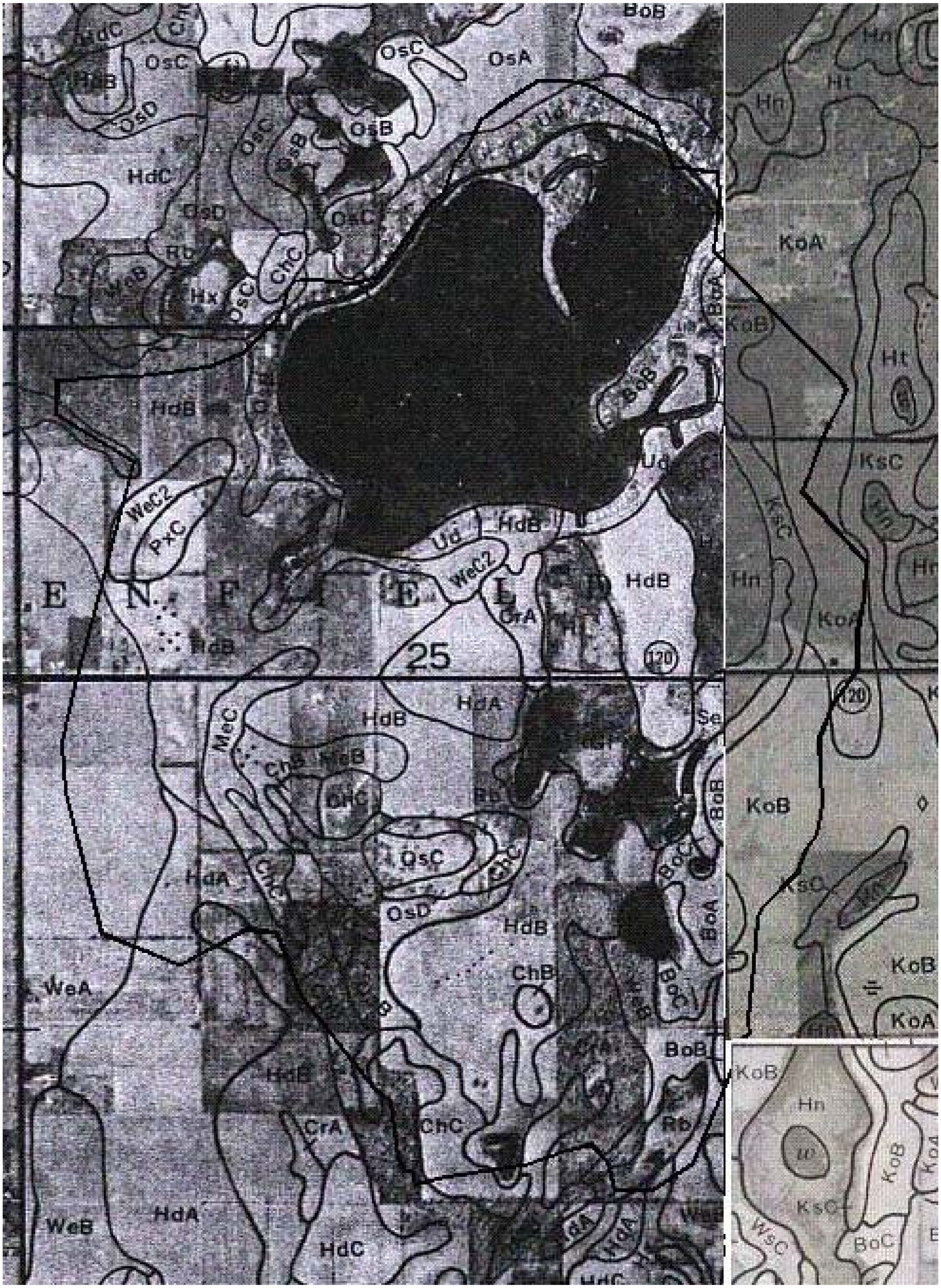
4.3 Purple Loosestrife, implications and control options

A number of Purple loosestrife *Lythrum salicaria* plants were noted growing along the Wall Lake shoreline. While watershed wetlands at Wall Lake show signs of disturbance through the presence of Reed canary grass, Purple loosestrife, an invasive European wetland plant has not yet appeared to any significant extent in wetlands away from the lake. A single loosestrife plant was found growing in the small wetland where the west tributary enters Wall Lake. (see picture 4.3-1 above) Since each of these plants is capable of producing 2.2 million seeds annually, this could lead to the spread of this plant upstream to the rest of the watershed's wetlands. Treatment was performed in 2005 with Renovate 3® (triclopyr) to kill this single plant but it may have produced viable offspring in this area because of the late-season timing of the treatment. Purple loosestrife was not noted to be growing in any other wetlands in the watershed. Because the spread of this plant to off-lake wetlands could potentially degrade the function of the watershed's wetland plant communities a control program should be initiated and will be a recommendation of this report. A reduction in plant diversity and habitat degradation may also result if these plants are allowed to spread. Purple loosestrife is not generally utilized as a food source by North American wildlife and carries little value in our native wetland plant assemblages. Once allowed to become established in area wetlands it is unlikely that this plant will ever be completely eradicated. Controlling lakeside Loosestrife plants as aggressively as possible can help prevent spread. Lake residents should be informed as to the ecological significance of this plant and encouraged to assist in the control efforts through association meetings and newsletters.

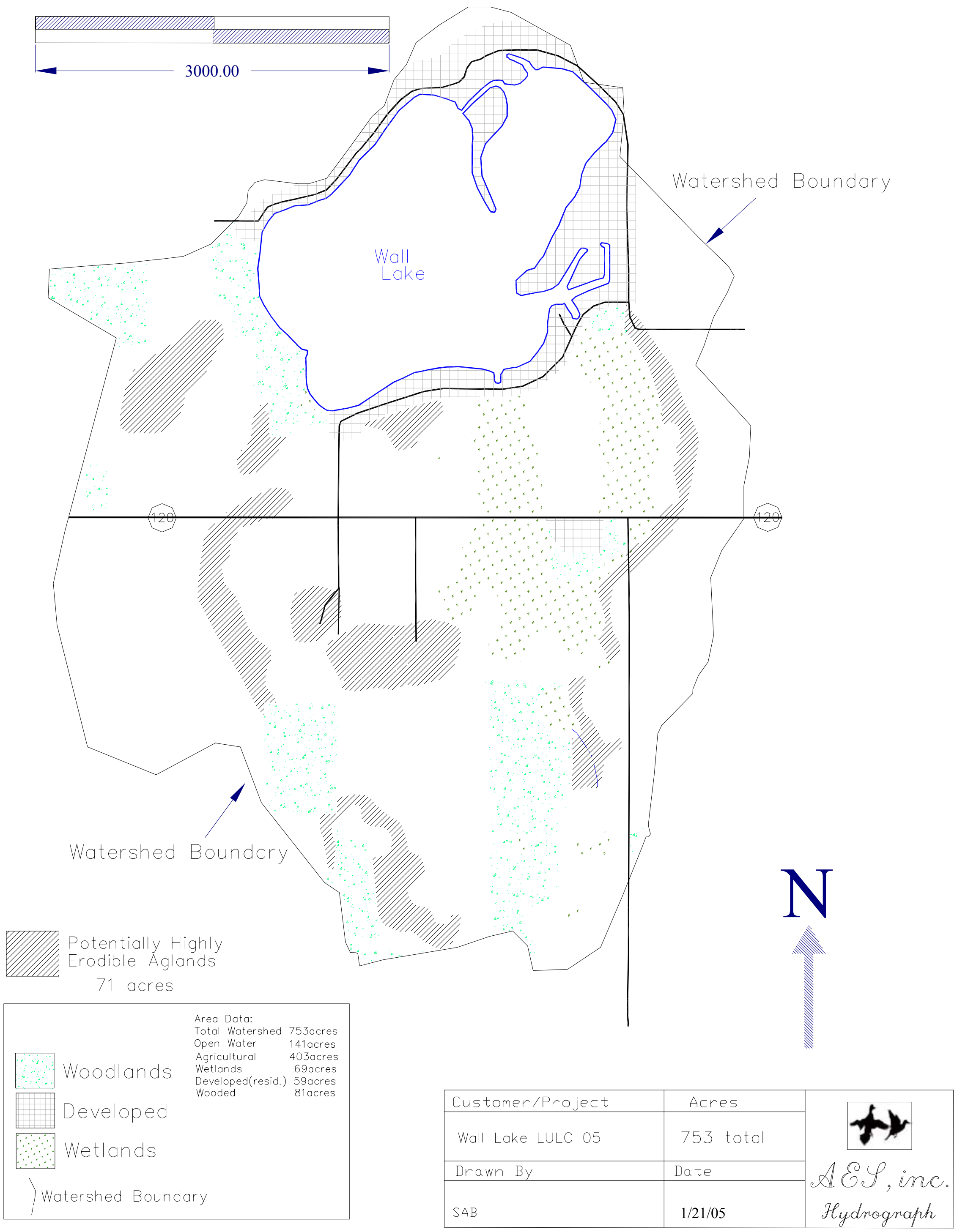
4.4 Soils

Information from the *Soil Survey of Lagrange County Indiana* and *Soil Survey of Steuben County Indiana* were used to characterize soils in the Wall Lake Watershed. The soil surveys were prepared by the USDA, Soil Conservation Service (now called Natural Resource Conservation Service) in cooperation with the Purdue University Agricultural Experiment Station. Through extensive efforts in field work, laboratory testing, and air photo interpretation in the 1970's, the surveys delineated soil units on maps and aerial photos. Two types of soil units are delineated in the surveys with "general" map units representing major associations of Steuben County and Lagrange County soil types on county maps. "Detailed" soil units are delineated on air photos and labeled according to the characteristics of soils or combinations of soils within each respective unit.(see map 4.4-1) The first (upper case) letter of the notation denotes the soil series. A soil series is named for a particular arrangement of soil layers and physical characteristics. The series is named for the first location at which it was described and recorded. The second (lower case) letter is used to distinguish soil types within a series. The third (upper case) letter, if included, designates the slope of the soil unit with "A" representing the least severe slope (0-2%) to E representing the most severe (18-25%). Soil units with no slope designation are relatively flat. The last character (number) if present, designates the degree of erosion evident, with "2" representing "eroded" areas and "3" representing "severely eroded". The southwest and northwest portions of Wall Lake's watershed lie within the Wawasee-Hillsdale-Conover and Boyer-Oshtemo major soil units. The Hillsdale-Conover unit is nearly level to strongly sloping, well drained in some areas and somewhat poorly drained in others, with moderately coarse textured and medium textured soils on till plains and moraines. The Boyer-Oshtemo unit is nearly level to moderately steep, well drained, coarse textured soil on outwash plains, valley trains, moraines, and kames.(USDA Lagrange 1980) The south eastern edge of the watershed lies within Steuben County in the Kusciusko-Ormas-Boyer major soil unit. This unit is nearly level to strongly sloping, well drained, loamy and sandy soils that are moderately deep or deep over sand and gravel on outwash plains and moraines. (USDA Steuben 1980) Much of the watershed is dominated by the Hillsdale sandy loam (HdB) soil unit. This unit has two to six percent slopes, and is deep and well drained. This soil is well suited to growing soy beans, corn, and small grain, but is susceptible to erosion. Hydrology and accumulation of organic material in the area wetland basins has established primarily Houghton muck, Ponded Houghton muck, and Gilford sandy loam soils in these areas.

Wall Lake's watershed contains approximately 71 acres of Highly Erodible Agricultural Lands (HEL). (see map 4.4-2 pg 82) For the purpose of this study most lands with a 6% slope or greater and all soil units with an "eroded" designation were considered to be HEL. Because the slopes and soil types on these lands make them highly susceptible to soil loss through erosion they will contribute nutrients and sediments to the lake and it's associated wetland systems. These areas should be given priority in terms of seeking the use of agricultural "best management practices" to minimize erosion. Working with landowners and county soil and water conservation district personnel to establish stabilizing long term vegetative cover to these areas will be a recommendation of this report.



Map 4.4-1 Wall Lake Watershed Soil Units, Source USDA Soil Survey



Map 4.4-2 Highly Erodible Agricultural Lands in the Wall Lake Watershed

4.5 Rare, Threatened and Endangered Species in the Wall Watershed

For this study a request was made for information on endangered, threatened, or rare species (ETR), high quality natural communities, and documented natural areas. Two vascular plants were indicated. Grooved Yellow Flax *Linum sulcatum* an Indiana State listed rare species was documented in the watershed in 1927. Grooved Yellow Flax is a one to two foot tall plant with nickel sized pale yellow flowers present in Late July through September. It generally grows on open terrain and is well adapted to growing on dry sandy or gravelly soils on prairie and savanna hillsides.

Photo 4.5-1 Grooved Yellow Flax Photo Courtesy of Newaygo Community Recreation and Natural Resource Conservation Planning Project

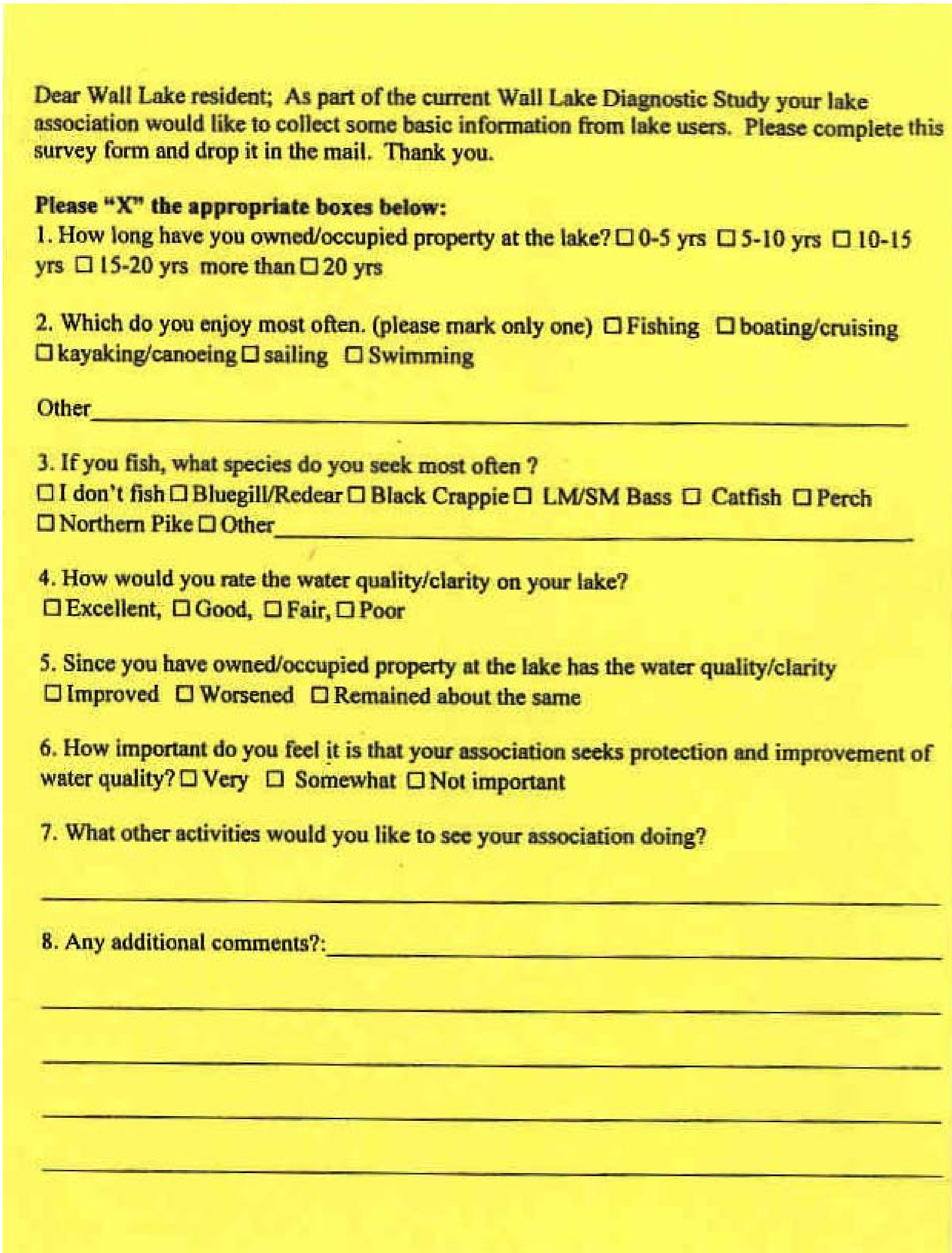
It is unknown whether this plant can still be found in the Wall Lake watershed. This plant may no longer be present. Preferring an open prairie or savanna environment it is likely that the original habitat of this plant was tilled for agriculture. Additionally the loss of the influence of periodic wildfires that played a part in excluding shading from woody growth on the Wall Lake Watershed has likely excluded habitat for this plant.

Photo 4.5-2 Prairie White Fringed Orchid, Photo courtesy of Wisconsin Department of Natural Resources

Prairie White Fringed Orchid *Platanthera leucophaea*, was also noted in the watershed in 1927. This plant is state classified as "endangered". This plant typically grows on wet mesic prairie, mesic prairies, and sedge meadows. It prefers calcareous, rich, sandy or black soils. It is unknown whether this plant can still be found in the Wall Lake watershed. This plant may also no longer be present. Preferring an open wet prairie or sedge meadow environment, it is likely that the original habitat of this plant has been altered by the introduction of non-native plants and wetland disturbance. Additionally the loss of the influence of periodic wildfires that probably played a part in excluding shading, woody growth on the Wall Lake wetlands has likely excluded habitat for this plant. The use of controlled burns, control of invasive disturbance oriented growth, and replanting of native wet prairie/sedge meadow plants can potentially reestablish the type of habitat needed by this plant.

5. The Wall Lake User Survey

During 2005 the survey card below was mailed to the Residents of Wall Lake to collect information about resident lake-use observations, preferences, and attitudes.



Dear Wall Lake resident; As part of the current Wall Lake Diagnostic Study your lake association would like to collect some basic information from lake users. Please complete this survey form and drop it in the mail. Thank you.

Please "X" the appropriate boxes below:

1. How long have you owned/occupied property at the lake? ☐ 0-5 yrs ☐ 5-10 yrs ☐ 10-15 yrs ☐ 15-20 yrs more than ☐ 20 yrs

2. Which do you enjoy most often. (please mark only one) ☐ Fishing ☐ boating/cruising ☐ kayaking/canoeing ☐ sailing ☐ Swimming

Other____________________

3. If you fish, what species do you seek most often ?
☐ I don't fish ☐ Bluegill/Redear ☐ Black Crappie ☐ LM/SM Bass ☐ Catfish ☐ Perch ☐ Northern Pike ☐ Other____________________

4. How would you rate the water quality/clarity on your lake?
☐ Excellent, ☐ Good, ☐ Fair, ☐ Poor

5. Since you have owned/occupied property at the lake has the water quality/clarity
☐ Improved ☐ Worsened ☐ Remained about the same

6. How important do you feel it is that your association seeks protection and improvement of water quality? ☐ Very ☐ Somewhat ☐ Not important

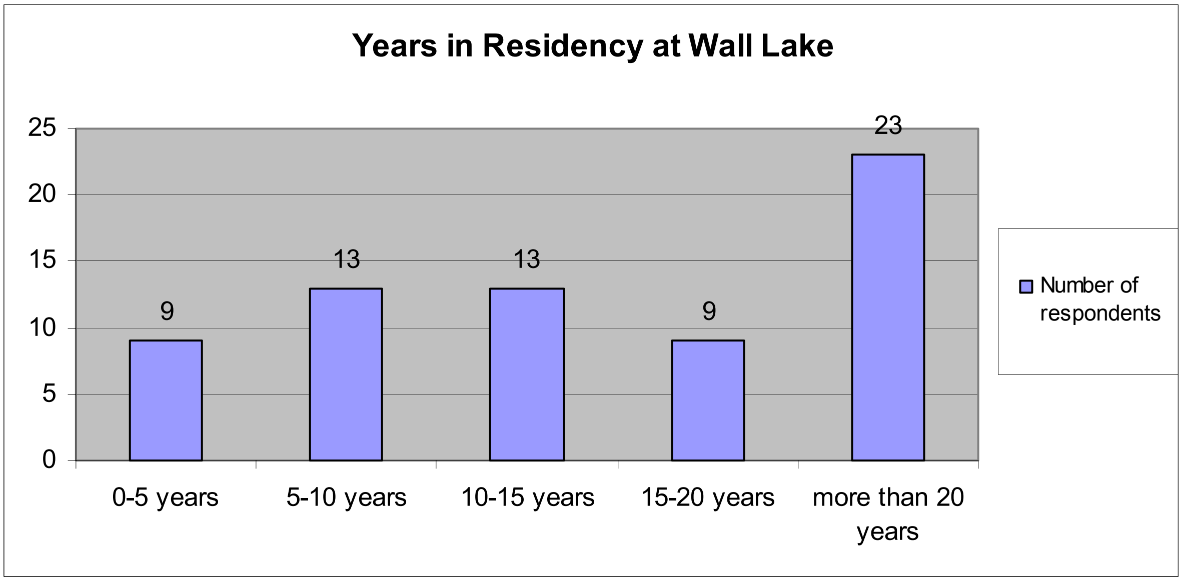
7. What other activities would you like to see your association doing?

____

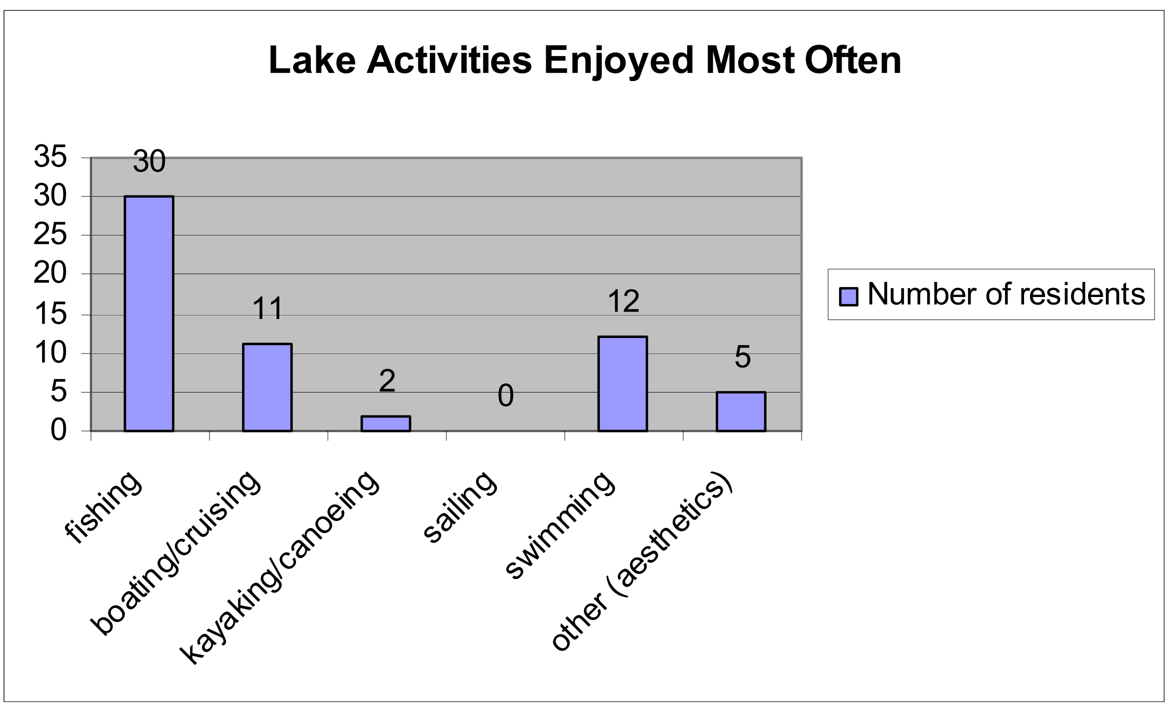
8. Any additional comments?:____________________

Figure 5-1 Wall Lake User Survey Card

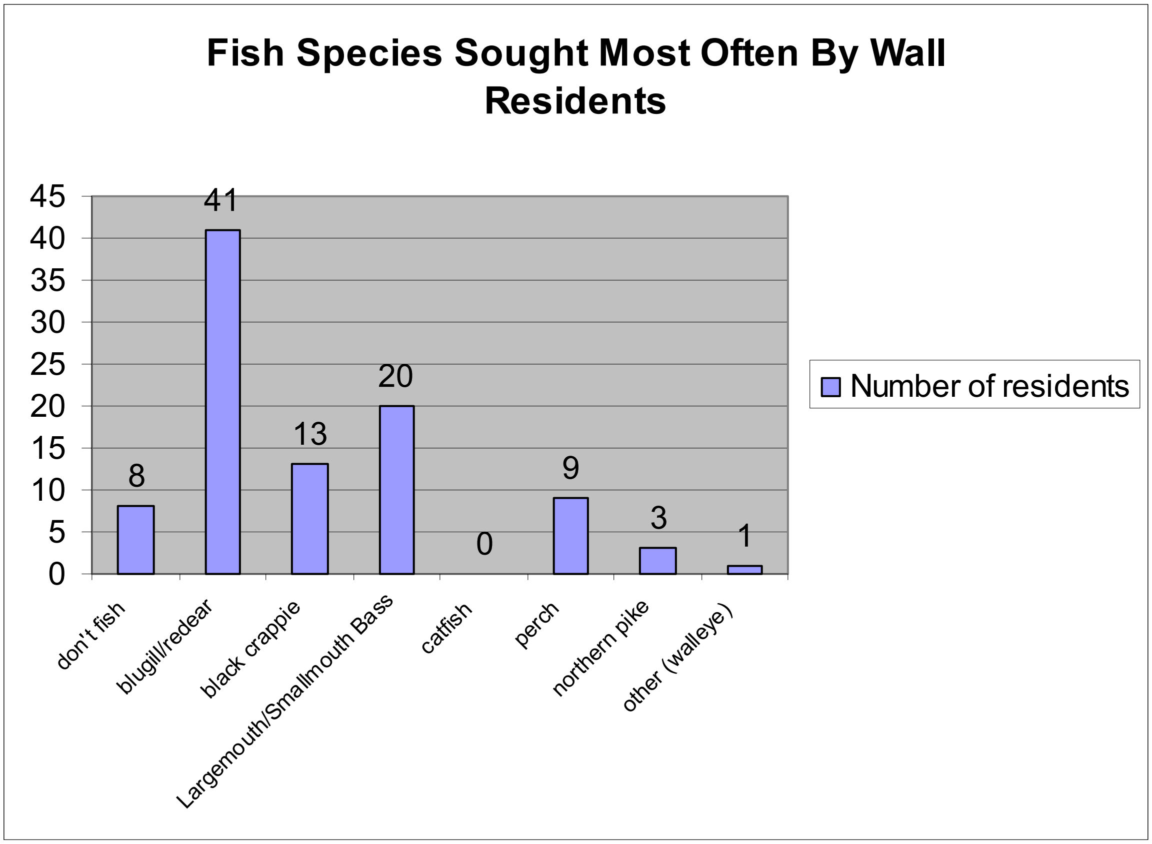
Sixty seven residents responded to the survey. In terms of the number of years they have lived or owned property at the lake Wall Lakes residents most commonly report 20 years or more at the lake (34% Graph 5-1). Fishing is by far the most popular activity at Wall Lake. One half of residents reported that fishing is the lake activity they enjoy most often. (Graph 5-2)



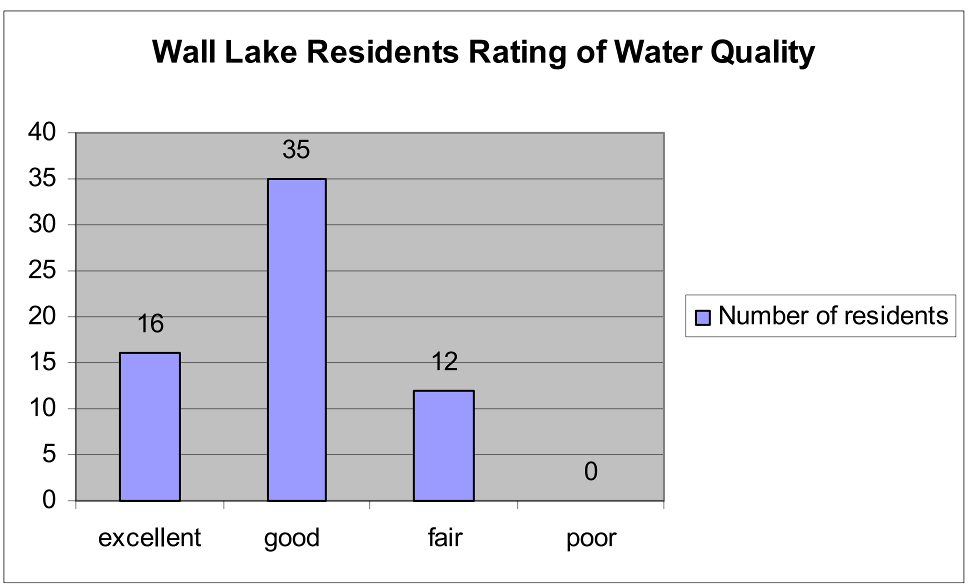
Graph 5-1 Years in Residency



Graph 5-2 Lake Activities

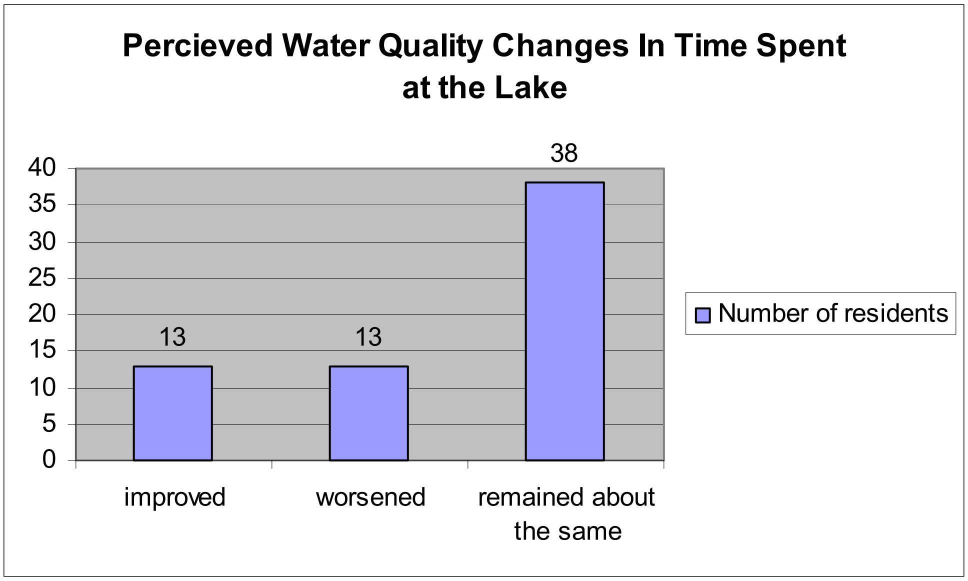


Graph 5-3 Fish Species Sought

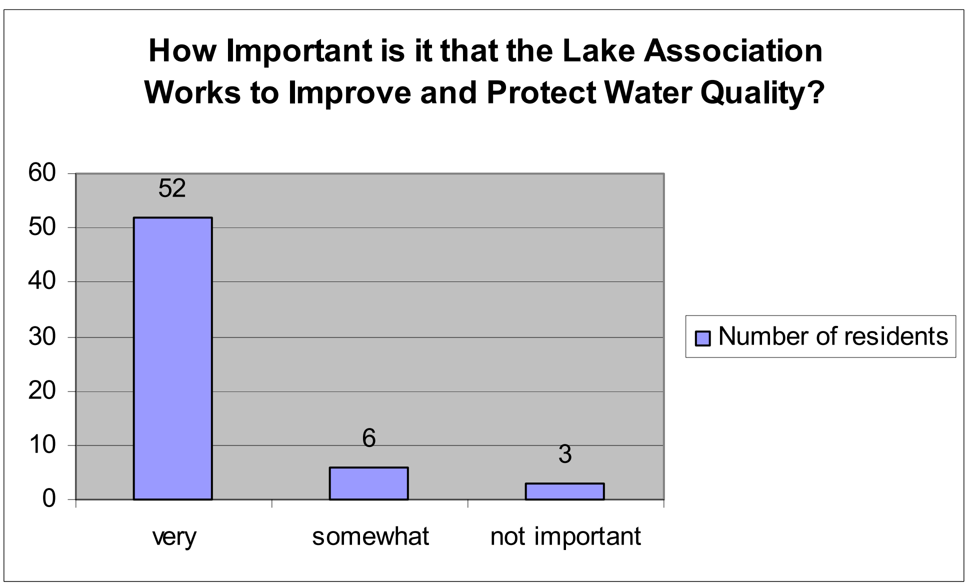


Graph 5-4 Ratings of Water Quality

Swimming and boating/cruising were also popular at 18 and 20 percent respectively. Bluegill were reported to be the most sought after species of fish, with bass fishing also reported as popular. (Graph 5-3) Fifty-five percent of respondents perceive their water quality to be good presently.(Graph 5-4) Twenty five percent ranked their current water quality as excellent. Nineteen percent felt that water quality was fair. No Wall Lake respondents indicated that they felt the water quality was poor.

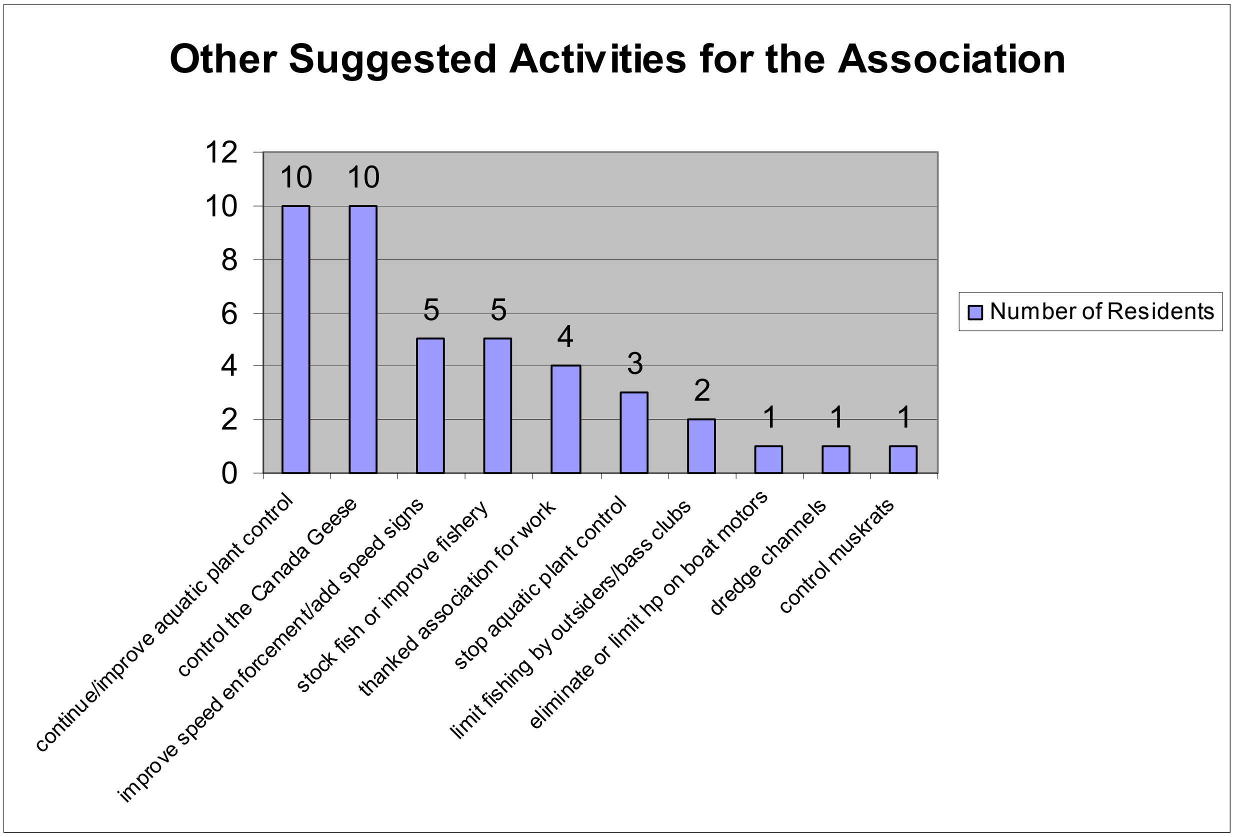


Graph 5-5 Perceived Water Quality Changes



Graph 5-6 Importance of Association Working to Improve Water Quality

Most of Wall Lake's residents (59%) feel that the lakes water quality has remained about the same in the time they have been at the lake. (Graph 5-5) Twenty percent indicated the water quality had improved and twenty percent indicated a worsening. Wall Lake's residents overwhelmingly feel that it is very important that the Association works to improve/protect water quality (85% Graph 5-6). Another ten percent felt it was somewhat important, and only five percent felt it was not important. When asked about which other issues they feel should be addressed at the lake the residents indicated broad support for continuing to address the Eurasian watermilfoil problems. (Graph 5-7) and controlling Canada Geese. Improving the enforcement of the ten mile-per-hour speed limit on Wall Lake was also a popular suggestion along with working to improve the Wall Lake fishery.



Graph 5-7 Suggested Association Activities

Three of 42 respondents indicated that they wanted the control of Eurasian watermilfoil stopped and two indicated that they would like to limit fishing by outsiders, including bass club functions held on the lake. Eliminating or limiting horsepower on gas engines, dredging the channels, and initiating control of the lakes muskrats were also mentioned. One of Wall Lake's most pressing problems is the lagging panfish growth rates noted by IDNR fisheries biologists. With the lake residents largely indicating that fishing for panfish is their favorite lake activity management activities that address the fishery problems should be granted priority status. The association's stocking of walleye in Wall Lake in the 2005 season should be a positive step, by offering an alternative target species to lake residents and also possibly helping with the bluegill growth rate problem. The problem with Eurasian watermilfoil will always be tied to this issue because of the potential of the plant to interfere with the fishery if the lake is colonized excessively. It would follow that overall water quality should also be a concern as limiting lake nutrients can be a positive long-term influence on the lake's plant community. The Wall Lake residents have already made much progress in addressing these issues and the survey provides evidence that lake residents are motivated to continue to support the association's lake management efforts.

6. Boating Use on Wall Lake

As part of this study the Wall Lake residents recorded boating use of the lake on one weekday and one Weekend day. On Friday August 12th and Saturday August 27th boat traffic present on the lake was recorded at hourly intervals between 9:00 a.m. and 5:00 p.m. Boats present on the lake and the type of use occurring were recorded according to the following tables:

Boat types	
pwc	personal watercraft, jet ski, seadoo etc.
fishing	bass boats, row boats etc.
I/O runabout	inboard/outboard, outboard speed boats, inboard ski boats
sailboat	
pontoon	
kayak/canoe	
pedal boat	

Table 6-1 Boating Survey Watercraft Types

Use types	
High speed	5 mph or above & producing significant wake
Low speed	trolling or cruising below 5 mph
anchored/still	at anchor or drifting, fishing with electric trolling motor in use
sailing	
ski	includes, tubing, skiing, wakeboarding, etc.

Table 6-2 Boating Survey Use Types

On Friday August 12th an average of 2.55 boats was present on the lake at each check. (Table 6-3) There was an average of 55.29 acres of surface water for each boat. Only one high speed (wake-making) boat was recorded. Most recorded boats were anchored or stopped. Overall traffic was moderately light for an Indiana public lake. For comparison Big and Little Otter Lakes in Steuben County (surveyed as a single lake) had an average of one boat per 74 acres present on the lake during a survey on Tuesday August 30, 2005, while Lake James, often considered a “busy” lake had an average of one boat per 19 acres on Friday July 29 of 2005.

Table 6-3 Friday 8/12/05 Wall Lake Weekday Boating Survey Results

Type of Watercraft	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.
pwc									
Fishing anchored	1	1			1				1
Fishing Low spd	1		1			1		1	
Fishing H. spd									
I/O runabout									
sailboat									
Pontoon anchored		2	1	2	1		1	1	1
Pontoon Low spd			1	1					1
Pontoon H spd	1								
kayak/canoe									
pedal boat				1	1				
Total Boats	3	3	3	4	3	1	1	2	3
Total H spd	1								

Average Boats Present	2.55
Total Avg. acres per boat	55.29
Average High Speed Boats Present	.11
Total Avg. acres per High Speed Boat (Avg. high speed boats recorded / lake acreage) The actual acreage of Wall Lake is only 141	1282

On Saturday August 27th an average of 5.56 boats was present on the lake at any given time between 9:00 a.m. and 5:00 p.m. (Table 6-4). This equates to 25.36 acres of surface water per boat at any given time. A total of five boats were recorded going fast enough to generate a significant wake. That equates to an average of 254 acres per high speed boat (average high speed boats present at a given time divided by lake acreage) and 25.36 acres per boat indicating a moderately light amount of weekend traffic for an Indiana lake. Obviously there would not actually be 210 acres of open water on Wall Lake per high speed boat because the lake is only 141 acres, but the 210 acre figure can be readily be used for comparison with other lakes surveyed using a similar protocol. In weekend data collected in August and September of 2005 the middle basin of Lake James had an average of one boat present per 12 acres and one high speed boat present per 16 acres. Big and Little Otter Lakes (also speed limited lakes like Wall) on the same weekend had a daytime average of one boat present per 10 acres and one high speed boat present per 98 acres.

Table 6-4 Saturday 8/27/05 Wall Lake Weekend Day Boating Survey Results

Type of Watercraft	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.
pwc									
Fishing anchored			1	1	3	1	3	2	2
Fishing Low spd			1			2			2
Fishing H. spd								2	
I/O runabout									
sailboat				1	1		1	1	
Pontoon anchored	2		1	1			2	2	
Pontoon Low spd	1	1	1			2	1	1	3
Pontoon H spd					1			1	1
kayak/canoe									1
pedal boat		1		1		1	1		
Total Boats	3	2	4	4	5	6	8	9	9
Total H spd					1			3	1

Average Boats Present	5.56
Total Avg. acres per boat	25.36
Average High Speed Boats Present	.56
Total Avg. acres per High Speed Boat (Avg. high speed boats recorded / lake acreage) The actual acreage of Wall Lake is only 141	254

On Friday August 26th 2005 the Wall Lake residents recorded launches and landings at the lake's public access ramp. (See table 6-5) Between 7:30 a.m. and 4:00 p.m. six launches and five landings were recorded. Time spent on the lake ranged from two hours to 4.83 hours. An average time of 3.3 hours was spent on the lake. Lake users who launched on this day launched fishing boats exclusively and the purpose of all the visits was fishing. Obviously the majority of users who access the lake at the public ramp do so for fishing. This is understandable with Wall Lake's ten mile-per-hour speed limit which excludes skiing and fast powerboating and encourages fisherman by offering a serene environment on the lake. This also reinforces that a high priority should be given to lake management practices that enhance the fishery at Wall Lake. Wall Lake residents should remain aware that the general public is likely to utilize the lake as a new walleye fishery and try to raise awareness and make sure restrictions on walleye harvest that will help maintain the fishery are followed.

Table 6-5 Friday 8/26/05 Public Launch Survey Data

Time Launched	Time Landed	Type of Boat	Type of Use	Hours spent
7:30	11:00	Fishing	Fishing	3.5
9:30	11:30	Fishing	Fishing	2
9:45	12:30	Fishing	Fishing	2.75
11:10	4:00	Fishing	Fishing	4.83
1:30	5:00	Fishing	Fishing	3.5
4:00	Unknown	Fishing	Fishing	

7. Zebra Mussels

Zebra Mussels *Dreissena polymorpha* were not noted growing in Wall Lake in the 2005 season, although they are present in many Indiana Lakes. There is often much concern over their presence and the potential for ecological changes in lakes where they appear. These thumbnail sized exotic mussels feed by filtering plankton from the surrounding waters (about 1 liter of filtered water each per day). Problems associated with these invaders include the sharp mussel shells cutting swimmer's feet in shallow areas, the clogging of water intakes, competition and extirpation of native mussels, and removal of phytoplankton from the water column. In lakes containing excessive nutrients the removal of phytoplankton can actually have a positive effect on water quality, at least in the short-term. However, changes in water chemistry on lake bottoms due to the excretion of waste by the zebra mussels may cause problems. This may affect fish spawning success and other processes crucial to maintaining a sportfishery. At the low mussel densities in Indiana's inland lakes the filtration effects are probably not yet an ecological issue. The most immediate hazard is that presented to barefoot swimmers who may cut their feet on the sharp edges of the mussel shells. As the tiny free-swimming life stage of the mussels (veligers) seek a hard substrate for attachment they may also present a problem by attaching and growing on boat hulls or in marine engine cooling systems. The zebra mussels in some cases may also cause extirpation of our own native mollusks. These pests which are native to the Caspian Sea region of Asia, have been present in European natural lakes for over 800 years and have only managed to colonize a small percentage of those lakes, so the extent of problems they will cause in North American inland lakes is not certain. Boaters should take precautions to prevent the spread of Zebra Mussels. The tiny free-living larval stage can remain viable in waters transported from the lakes. Draining of bilge water, livewell water, and flushing of engine cooling systems with a 10% bleach solution can help prevent the transport of live veligers. Also, leaving a boat out of water for several days will do the trick. Any adult spotted on a boat hull should be removed before transport. A single adult female zebra mussel is capable of producing 1 million eggs per year. Wall Lake is susceptible to colonization by zebra mussels because of use by area fisherman that may transport water from other lakes. The introduction of walleye to Wall Lake will probably increase this risk. To help curb the problem the Wall Lake association should begin by raising awareness about the mussels among lake residents to try to prevent spread by the residents who launch on the lake. It may also be wise to talk to bass clubs who hold outings on the lake about raising awareness of the problem among members if they do not already. Clear posting of signs at the launch to raise awareness of the problem, or talking to boaters who are launching may also be wise. These same steps can also help prevent the introduction of new problem aquatic plant species to Wall Lake.

8. Recommendations

1. Work with Watershed Property Owners to Seek Long Term Legal Protection of Watershed Wetlands and Woodlands

The Wall Lake Fisherman's Association should work with watershed property owners who may be interested in establishing conservation easements, deed restrictions, or other arrangements that permanently protect the watershed's wetlands or woodlands and their vegetative cover from destruction. The remaining watershed wetlands and woodlands serve a valuable purpose in regulating the introduction of nutrients to Wall Lake, especially from the Southern portion of its watershed. Government protection of private wetlands is often challenged in the courts and no guarantee exists that remaining wetlands will not be subject to legalized drainage or filling in the future. Many owners of wetland or woodland areas enjoy the beauty and recreation these lands offer and can enjoy significant advantages in establishing formal protection of these lands in perpetuity while still retaining rights to their use and enjoyment.

2. Initiate a control program for Purple Loosestrife to prevent the spread of this invasive plant to the watershed's wetlands

This invasive non-native plant has begun to grow along the shoreline of Wall Lake but has not yet spread into the watershed wetlands. Initiating a control program now, including spraying, cutting, or removal of plants may prevent its eventual domination of area wetlands. The potential exists for habitat degradation and loss of wetland function in terms of lake water quality if this plant is allowed to spread. Keeping lake residents aware of this plant and the purpose of controlling it will be important.

3. Continue Direct Fish Management Activities to Enhance the Wall Lake Fishery

Both resident and non-resident users of Wall Lake primarily use the lake for fishing, with pan-fishing being extremely popular, yet panfish growth rates at Wall Lake lag behind most other Indiana lakes. While some lake users indicate they enjoy good panfish catches at Wall Lake there is room for improvement based on IDNR fish sampling. The walleye stocking at Wall Lake in 2005 will hopefully be a positive step toward improving the fishery that can be continued in future seasons. The Wall Lake Fisherman's Association should continue to work with IDNR fisheries biologists to evaluate the effectiveness of this stocking both in producing a walleye fishery and possibly providing a reduction in bluegill numbers and improvement to bluegill growth rates. The program should be continued if effective. Carrying out a selective reduction in bluegill numbers through the application of piscicides should continue to be considered as a possible management activity to improve panfish growth rates.

4. Seek the Reduction of Nutrient Contributions from Lakeside Residences

Because estimates indicate that a large portion (39%) of Wall Lake's phosphorus budget has its origin in lakeside septic systems, connection of lakeside residences to a centralized sewage collection system can rapidly act to protect water quality at Wall Lake more so than other management activities. Keeping Wall Lake residents aware of the ramifications of lawn fertilization will also be important. In some cases the use of Phosphorus-free fertilizers may be of benefit, especially if soils present already contain sufficient phosphorus.

5. Continue to Pursue the Goals Established in the Wall Lake Aquatic Vegetation Management Plan Through the Lake and River Enhancement Program.

The whole-lake fluridone treatment performed at Wall Lake in 2005 shows promise in providing long term relief from Eurasian watermilfoil colonization. Maintaining a diverse native aquatic plant community at Wall Lake will allow for easier recreational use of the lake, improve lake aesthetics, and also compliment efforts toward managing the fishery and general water quality. Encourage the annual re-examination of the plan and the annual re-evaluation of management activity results with consideration given to all management options. The association should continue to provide meeting forums where all opinions about management options can be heard and continue to also use these meetings as an opportunity to increase awareness of the nature of the problem and the implications of management options.

6. Work with Watershed Property Owners to Seek the Enhancement of Watershed Wetlands

The Wall Lake Fisherman's Association may be able to work with watershed property owners to help manage vegetation and ground cover on the area wetlands to maintain beneficial diverse native plant communities. Activities such as controlled burns, seeding of native plants, or the establishment of vegetated filter strips on farm grounds adjacent to wetlands can help eliminate or limit colonization by invasive non-native plants such as Purple loosestrife or Reed canary grass and benefit wildlife and water quality. It may be possible to further defeat Preexisting ditching in the lake's west wetland area to better restore the original hydrology of this area. Initiating an aggressive program in to eradicate or reduce purple loosestrife in the watershed will also be important for these areas.

7. Work with Area Landowners, County Soil and Water Conservation Staff, and the USDA Natural Resources Conservation Service to maximize the application of Best Management Practices on Agricultural Lands in the Watershed.

Long-term vegetative cover should be sought on agricultural lands that are highly erodible to help prevent the transport of sediment and associated nutrients to the lake and wetlands. This can include placing lands in the conservation reserve program or establishing new filter strips and grassed waterways in key areas.

9. Helpful Lake Management Conferences and Workshops

Wall Lake residents can attend the following events to learn more about lake management and converse with other lake associations and lake management professionals regarding lake and watershed improvement.

November 8-10, 2006 26th International Symposium of the North American Lake Management Society, Indianapolis, IN, More information is available at www.indianalakes.org or by calling 260-665-8226

October 2006, Several local workshops offered by the Indiana Lakes Management Society, dates to be announced. More information is available at www.indianalakes.org or by calling 260-665-8226

10. Sources of Local, State, and Federal Funding and Information

Funding assistance for wetland and grassland restoration is available from:

Ducks Unlimited
Great Lakes/Atlantic Regional Office
331 Metty Drive, Suite #4
Ann Arbor, MI 48103
734-623-2000

Pheasants Forever, Northeast Indiana Chapter
Habitat Officer, Dave Hurley
1003 County Road 8
Corunna, IN 46730

Other help for watershed improvements can be obtained from:

Indiana Department of Natural Resources
Division of Fish and Wildlife Room W265
402 W. Washington Street
Indianapolis, IN 46204-2739
317-233-5468

USDA Natural Resources Conservation Service
1220 N 200W
Angola, IN 46703

Wood-Land-Lakes RC&D
Peachtree Plaza 200
1220 N 200 W -Ste J
Angola, IN 46703
260-665-3211, Ext. 5

Land Trusts:

Blue Heron Ministries, Inc.
c/o The Presbyterian
Chapel of the Lakes
2955 West Orland Road
Angola, IN 46703

ACRES, Inc.
2000 North Wells Street

Fort Wayne, Indiana 46808-2474

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Columbia City, Indiana 46725

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Data Sources

Pan Evaporation data- National Climatic Data Center, 151 Patton Ave., Asheville, NC Cooperative Station 127102, Prairie Heights, IN

Pan Evaporation coefficient- Linacre, E.T. 1994. Estimating U.S. Class-A pan evaporation from few climate data. *Water International 19*, 5 - 14.

Angola, IN rainfall data (modeling)- Midwestern Regional Climatic Center, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820-7495, Cooperative Station 120200, Angola, IN

Angola, IN rainfall data (storm event sampling)- Northwood Subdivision Weather Station, Angola, IN, through Weather Underground, Ann Arbor, MI. http://www.wunderground.com/

Flow data, Lime Lake Outlet- U.S. Geological Survey, Water Resources Division, 5957 Lakeside Boulevard, Indianapolis, IN 46278-1996

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Appendix A
Lake Sampling Laboratory Forms

Edglo Laboratories, Inc.
www.edglo.com
2121 E Washington Blvd. Fort Wayne, IN 46803
(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0826053804	9/12/05	From:
Date Received	Sample Matrix	
8/26/05 4:25:00 PM	Water	To: 8/26/05 7:05:00 PM
Sample ID		
Wall Lake EPI		

Report of Analysis

Parameter	Method Code	MDL		Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01		0.02	mg/L	9/8/05 10:30:00 AM	BK
Nitrate	EPA 300.0	0.01	<	0.01	mg/L	8/26/05 7:50:00 PM	BM
Nitrite	EPA 300.0	0.01	<	0.01	mg/L	8/26/05 7:50:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	<	0.007	mg/L	9/6/05 3:00:00 PM	BK
Phosphorus Dissolved	EPA 365.1	0.007	<	0.007	mg/L	9/6/05 3:00:00 PM	BK
Specific Conductivity	EPA 120.1	1		341	µS/cm@25C	8/29/05 10:53:00 AM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08		2.16	mg/L	9/7/05 10:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007	<	0.007	mg/L	9/6/05 3:00:00 PM	BK
Turbidity	EPA 180.1	0.1		1.70	NTU	8/27/05 12:30:00 PM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

Edglo
Laboratories, Inc.
www.edglo.com
2121 E Washington Blvd. Fort Wayne, IN 46803
(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Laboratory #	Report Date	Date/Time Sampled
0826053803	9/12/05	From:
Date Received	**Sample Matrix**	
8/26/05 4:25:00 PM	Water	To: 8/26/05 7:20:00 PM
Sample ID		
Wall Lake HYP		

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Report of Analysis

Parameter	Method Code	MDL		Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01		0.54	mg/L	9/8/05 10:30:00 AM	BK
Nitrate	EPA 300.0	0.01	<	0.01	mg/L	8/26/05 7:50:00 PM	BM
Nitrite	EPA 300.0	0.01	<	0.01	mg/L	8/26/05 7:50:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007		0.011	mg/L	9/6/05 3:00:00 PM	BK
Phosphorus Dissolved	EPA 365.1	0.007		0.21	mg/L	9/6/05 3:00:00 PM	BK
Specific Conductivity	EPA 120.1	1		419	µS/cm@25C	8/29/05 10:53:00 AM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08		3.28	mg/L	9/7/05 10:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007		0.145	mg/L	9/6/05 3:00:00 PM	BK
Turbidity	EPA 180.1	1		61.5	NTU	8/27/05 12:30:00 PM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

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email: pknott@edglo.com

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Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0826053801	8/29/05	**From:**
Date Received	**Sample Matrix**	
8/26/05 4:25:00 PM	Water	**To:** 8/26/05 1:25:00 PM
Sample ID		
Wall Lake EPI		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ecoli	600-A-85-076	1	< 1	CFU/100ml	8/26/05 4:40:00 PM	BM

< is less than reported detection limit
Certification Number: INC0203
Page 1

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Ed Guindon, President

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Laboratories, Inc.

www.edglo.com
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P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0826053802	8/29/05	**From:**
Date Received	**Sample Matrix**	
8/26/05 4:25:00 PM	Water	**To:** 8/26/05 1:20:00 PM
Sample ID		
Wall Lake HYP		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ecoli	600-A-85-076	1	15	CFU/100ml	8/26/05 4:40:00 PM	BM

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

EDGLO LABORATORIES, INC. SAMPLE CHAIN OF CUSTODY FORM

CLIENT/COMPANY NAME: AQUATIC ENHANCEMENT

PROJECT/SITE NAME: WALL LAKE

SAMPLER (SIGNATURE): [signature]

REMARKS:

COLLECTION TIME	COLLECTION DATE	SAMPLE LOCATION DESCRIPTION	SAMPLE PRESERVATION	Sample Type GRB.	CMP	Matrix	Edglo LIMS Laboratory No.	TOTAL PHOS	NITRATE	NITRITE	CONDUCTIVITY	DISCHARGE	TKN	AMMONIA NITROGEN	ORTHO PHOS	TOTAL DISSOLVED PHOS	TURBIDITY	E-COLI
7:20pm	8/24	WALL LAKE HYP	H_2SO_4	X			0826053803	X										
7:05pm	8/24	WALL LAKE EPI WPT108	H_2SO_4	X			0826053804	X										
7:05pm	8/24	WALL LAKE EPI WPT108	UNP	X			0826053805		X	X	X	X	X	X	X	X	X	
7:20PM	8/24	WALL LAKE HYP	UNP	X			0826053803		X	X	X	X	X	X	X	X	X	
1:25	8/26	WALL LAKE EPI		X			0826053801											X
1:20	8/26	WALL LAKE HYP		X			0826053802											X
		~~WALL~~																

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
[signature]	8/26/05	2:54	[signature]
[signature]	8/26/05	4:25	[signature]

Temperature Preservation:
Suggested Range: 4+-3C
Internal Temp @ Receipt:
[deg C]

PRESERVATIVE CODES

UNP = Unpreserved
HNO3 = Nitric Acid, pH < 2 s.u.
H2SO4 = Sulfuric Acid, pH < 2 s.u.
HNO3 = Nitric Acid, pH < 2 s.u.
NaOH = Sodium Hydroxide, pH > 10 s.u.
HCl = Hydrochloric Acid, pH < 2 s.u.
ZnOAc = Zinc Acetate (w/NaOH)
NaT = Sodium Thiosulfate
Headspace in VOA Vials? Y N
Sample Seal Intact (If App)? Y N
MATRIX: W = Water S = Solids/Semi-Solids

Sampling Notes - Special Laboratory Instructions:
See attached for detection limits
CONCENTRATE FOR .007 PPM PHOS. DETECT. LIMIT.

2121 EAST WASHINGTON BOULEVARD FORT WAYNE, INDIANA 46803 PHONE: 260-424-1622 800-891-8442 FAX: 260-424-9124 WWW.EDGLO.COM

HOOSIER MICROBIOLOGICAL
HML
LABORATORY

Testing • Research • Consulting

Multiple Analysis Report

Sample: 138431
September 28, 2005

Mr. Rick Holy
Edglo Labs, Inc.
2121 E. Washington Blvd.
Ft. Wayne, IN 46803

RE: PWS ID#: Unavailable
Aquatic Enhancement
Wal Lake WPT 108
Unavailable
Unavailable

Dear Mr. Holy:

The following are the result(s) of the test(s) performed on the sample(s) received at HML, Inc. at 10:18 AM, 08/31/2005, and collected at 1:25 PM, 08/26/2005:

TEST - METHOD	RESULT	MDL*	Date Complete
Chlorophyll-SM10200H	1.8 mg/m*3	0.1 mg/m^3	09/16/2005

*Minimum Detection Level

This testing was completed by T.F. Please feel free to contact us if we can be of further service to you.

Sincerely,

Donald A. Hendrickson

Donald A. Hendrickson, Ph.D.
President - Microbiologist
Chemistry Lab #C-18-01
Microbiological Lab #M-18-03

DAH/skp

Appendix B
Lake Sampling Raw Data Sheet

LAKE WALL	TIME 6:20PM	LOCATION 34' WPT 108 LARGE BASIN	WEATHER 71° SUN E 0-5	DATE 8/24/05
			SECCHI 13.1 FT.	

PROFILE DEPTH (m) pH		TEMP (C)	O2	COND (US)
8.65	S	25.2	8.01	310
8.67	1.00	25.3	8.05	310
8.66	2.00	25.3	8.18	310
8.62	3.00	25.2	8.13	310
8.54	4.00	24.5	7.81	307
8.34	5.00	24.2	7.47	308
7.59	6.00	20.~~x~~3	.79	327
7.51	7.00	16.7	.44	300
7.50	8.00	14.3	.08	286
7.46	9.00	12.3	.06	310
7.23	10.00	11.8	.04	~~314~~ 317
	11.00			
	12.00			
	13.00			
	14.00			
	15.00			
	16.00			
	17.00			
	18.00			
	19.00			
	20.00			
	21.00			
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	27.00			
	28.00			
	29.00			
	30.00			
	31.00			
	32.00			
	33.00			
	34.00			
	35.00			
	36.00			
	37.00			
	38.00			
	39.00			

PLANKTON TOW FROM 10 METERS (1?, LIGHT) (BOTTOM)

(NOT ACTUALLY 11 M. DEEP)

BOTTOM

HYP SAMPLES COLLECTED @ 9 M

Appendix C
Tributary Baseline Sampling Laboratory Report Forms

Edglo
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www.edglo.com
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(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0817052278	9/ 8/05	From:
Date Received	**Sample Matrix**	
8/17/05 1:40:00 PM	Water	To: 8/17/05 10:45:00 AM
Sample ID		
Lake James Chain - Wall Lake East Trib		

Report of Analysis

Parameter	Method Code	MDL		Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01		0.12	mg/L	8/23/05 10:30:00 AM	BK
Nitrate	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Nitrite	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	<	0.007	mg/L	8/25/05 4:00:00 PM	BK
Specific Conductivity	EPA 120.1	1		644	µS/cm@25C	8/26/05 2:27:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08		1.60	mg/L	8/23/05 8:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007		0.013	mg/L	8/25/05 4:00:00 PM	BK
Turbidity	EPA 180.1	10		933	NTU	8/19/05 6:30:00 PM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

Edglo

Laboratories, Inc.

www.edglo.com

2121 E Washington Blvd. Fort Wayne, IN 46803

(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124

email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0817052279	9/ 8/05	**From:**
Date Received	**Sample Matrix**	
8/17/05 1:40:00 PM	Water	**To:** 8/17/05 11:05:00 AM
Sample ID		
Lake James Chain - Wall Lake West Trib		

Report of Analysis

Parameter	Method Code	MDL		Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01		0.22	mg/L	8/23/05 10:30:00 AM	BK
Nitrate	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Nitrite	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.014		0.226	mg/L	8/25/05 4:00:00 PM	BK
Phosphorus Dissolved	EPA 365.1	0.007		0.072	mg/L	9/6/05 3:00:00 PM	BK
Specific Conductivity	EPA 120.1	1		740	µS/cm@25C	8/26/05 2:27:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08		3.20	mg/L	8/23/05 8:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.014		1.39	mg/L	8/25/05 4:00:00 PM	BK
Turbidity	EPA 180.1	0.1		2.50	NTU	8/19/05 6:30:00 PM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

EDGLO LABORATORIES, INC. — SAMPLE CHAIN OF CUSTODY FORM

CLIENT/COMPANY NAME: AQUATIC ENHANCEMENT

PROJECT/SITE NAME: WALL LAKE ~~/CONCORDE CREEK~~

SAMPLER (SIGNATURE): [signature]

REMARKS:

ANALYTICAL TESTS REQUESTED: NITRATE+NITRITE; TKN; AMMONIA NITROGEN; T. PHOS.; ORTHO PHOS. / ~~DISSOLVED PHOS.~~; TURBIDITY; CONDUCTIVITY; DISCHARGE

COLLECTION TIME	COLLECTION DATE	SAMPLE LOCATION DESCRIPTION	SAMPLE PRESERVATION	Sample Type GRB.	Sample Type CMP	Sample Type Matrix	Edglo LIMS Laboratory No.
7:36	7/16/05	WALL EAST TRIB. RAIN	UNP	X			0718052077
7:41	7/16/05	WALL WEST TRIB. RAIN	UNP	X			0718052078
7:41	"	WALL EAST TRIB. RAIN	H_2SO_4	X			
7:35	"	WALL WEST TRIB. RAIN	H_2SO_4	X			

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
[signature]	7/18/05	1235	X [signature]
X [signature]	7/18/05	2:45	Donald D [illegible] II

Temperature Preservation:
Suggested Range: 4 +- 3C
Internal Temp @ Receipt:
[deg C]

PRESERVATIVE CODES

- UNP = Unpreserved
- HNO3 = Nitric Acid, pH < 2 s.u.
- H2SO4 = Sulfuric Acid, pH < 2 s.u.
- HNO3 = Nitric Acid, pH < 2 s.u.
- NaOH = Sodium Hydroxide, pH > 10 s.u.
- HCl = Hydrochloric Acid, pH < 2 s.u.
- ZnOAc = Zinc Acetate (w/NaOH)
- NaT = Sodium Thiosulfate

Headspace in VOA Vials? Y N

Sample Seal Intact (If App)? Y N

MATRIX: W = Water S = Solids/Semi-Solids

Sampling Notes - Special Laboratory Instructions: QUESTIONS? CALL CELL 260-668-5062

*PLEASE CONCENTRATE SAMPLE FOR .007 PPM PHOS. DETECTION LIMIT (& ORTHO)

I NEED ALL PARAMETERS LISTED RUN FOR EACH OF THESE (2) LOCATIONS. PLEASE SELECT FROM APPROPRIATE PRESERVATION.

*DO NOT RUN ALL PARAMETERS FOR ALL 4 CONTAINERS

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Edglo
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(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0817052278	9/ 8/05	From:
Date Received	**Sample Matrix**	
8/17/05 1:40:00 PM	Water	To: 8/17/05 10:45:00 AM
Sample ID		
Lake James Chain - Wall Lake East Trib		

Report of Analysis

Parameter	Method Code	MDL		Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01		0.12	mg/L	8/23/05 10:30:00 AM	BK
Nitrate	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Nitrite	EPA 300.0	0.01	<	0.01	mg/L	8/17/05 6:10:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	<	0.007	mg/L	8/25/05 4:00:00 PM	BK
Specific Conductivity	EPA 120.1	1		644	µS/cm@25C	8/26/05 2:27:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08		1.60	mg/L	8/23/05 8:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007		0.013	mg/L	8/25/05 4:00:00 PM	BK
Turbidity	EPA 180.1	10		933	NTU	8/19/05 6:30:00 PM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

Edglo
Laboratories, Inc.

www.edglo.com
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(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Laboratory #	Report Date	Date/Time Sampled
0719052078	8/ 3/2005	From:
Date Received	**Sample Matrix**	
7/18/2005 2:45:00 PM	Water	To: 7/16/2005 7:41:00 AM
Sample ID		
Wall - West Trib. Rain		

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01	0.19	mg/L	7/29/2005 9:00:00 AM	BK
Nitrate + Nitrite	EPA 300.0	0.01	0.26	mg/L	7/18/2005 12:42:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	0.142	mg/L	8/1/2005 12:30:00 PM	BK
Specific Conductivity	EPA 120.1	1	308	µS/cm@25C	7/20/2005 4:15:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08	1.60	mg/L	7/27/2005 7:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007	0.287	mg/L	8/1/2005 12:30:00 PM	BK
Turbidity	EPA 180.1	0.5	19.1	NTU	8/2/2005 11:00:00 AM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

EDGLO LABORATORIES, INC.

SAMPLE CHAIN OF CUSTODY FORM

CLIENT/COMPANY NAME: AQUATIC ENHANCEMENT

PROJECT/SITE NAME: LAKE JAMES CHAIN DIAGNOSTIC STUDY / WALL LK STUDY

SAMPLER (SIGNATURE):

REMARKS:

COLLECTION TIME	COLLECTION DATE	SAMPLE LOCATION DESCRIPTION	SAMPLE PRESERVATION	Sample Type GRB.	CMP	Matrix	Edglo LIMS Laboratory No.	ANALYTICAL TESTS REQUESTED
9:30	8/17	BIG OTTER TRIB Baseline	UNP	X				SEE BELOW *
10:20	8/17	WALL EAST TRIB Baseline	H_2SO_4	X				" " *
9:15am	8/17	WISPER BAY TRIB	H_2SO_4	X				" " "
9:50am	8/17	FOLLET CREEK BASELINE	"	X				" " "
8:55am	8/17	N SNOW BAY TRIB	"	X				" " "
11:05am	8/17	WALL LAKE WEST TRIB	"	X				" " "
9:04am	8/17	CROOKED CREEK	"	X				" " "
9:50am	8/17	BIG OTTER TRIB Baseline	"	X				" " "
8:20am	8/17	SOWLES BAY TRIB BASELINE	"	X				" " "

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)

Temperature Preservation:

Suggested Range: 4 +- 3C

Internal Temp @ Receipt:

[deg C]

PRESERVATIVE CODES

- UNP = Unpreserved
- HNO3 = Nitric Acid, pH < 2 s.u.
- H2SO4 = Sulfuric Acid, pH < 2 s.u.
- HNO3 = Nitric Acid, pH < 2 s.u.
- NaOH = Sodium Hydroxide, pH > 10 s.u.
- HCl = Hydrochloric Acid, pH < 2 s.u.
- ZnOAc = Zinc Acetate (w/NaOH)
- NaT = Sodium Thiosulfate

Headspace in VOA Vials? Y N

Sample Seal Intact (If App)? Y N

MATRIX: W = Water S = Solids/Semi-Solids

Sampling Notes - Special Laboratory Instructions:

ON T. PHOS & ORTHO PHOS. PLEASE CONCETRATE FOR .007 PPM DETECTION LIMIT

CONDUCTIVITY, DISCHARGE
T. PHOS., DISSOLVE PHOS., TURBIDITY

* ONE PRESERVED & ONE UNPRESERVED TAKEN AT EACH SITE - NEED: NITRATE, NITRITE, TKN, AMMONIA N,

2121 EAST WASHINGTON BOULEVARD FORT WAYNE, INDIANA 46803 PHONE: 260-424-1622 800-891-8442 FAX: 260-424-9124 WWW.EDGLO.COM

← SEE ALSO ATTACHED * PLEASE SELECT APPROPRIATE BOTTLE - MY NUMBER (260) [illegible]

Appendix D
Tributary Baseline Sampling Raw Field Data Sheet

BASELINE Samples

Sheet1

Tributary 1 Name West OTTER TRIB

Tributary Width in inches	
Tributary Depth in Inches Point 1	
Trilbutary Depth in Inches Point 2	
Tributary Depth in Inches Point 3	
Tributary Depth in Inches Point 4	
Tributary Depth in Inches Point 5	
Tributary Depth in Inches Point 6	
three feet in how many seconds	
Total Phosphorus	
Nitrates	
TSS	

6ft wide 3ft in 7sec

D.O 8.21

Depths 0.in, 15.in, 20 in, 18 in, 18 in, 12 in

% Sat 82.3 Salinity 4ppt

TEMP 17.3°C

COND 685us Specific Conductants 803us

PH 7.8 TEMP 15.8°C -64mv

Tributary 2 Name Follet Creek

Tributary Width in inches	
Tributary Depth in Inches Point 1	
Trilbutary Depth in Inches Point 2	
Tributary Depth in Inches Point 3	
Tributary Depth in Inches Point 4	
Tributary Depth in Inches Point 5	
Tributary Depth in Inches Point 6	
three feet in how many seconds	
Total Phosphorus	
Nitrates	
TSS	

Gage level is at 5.2 3ft in 8sec.

Depths 29 in, 25 in, 24 in, 20 in, 12 in, 5 in

D.O. 5.27 Salinity .4ppt

%SAT 54.5

TEMP 25.2°C

COND 739us Specific Conductants 735

PH 7.95 TEMP 24.6°C -72mv

Tributary 3 Name Wall Lake East Trib

Tributary Width in inches	
Tributary Depth in Inches Point 1	
Trilbutary Depth in Inches Point 2	
Tributary Depth in Inches Point 3	
Tributary Depth in Inches Point 4	
Tributary Depth in Inches Point 5	
Tributary Depth in Inches Point 6	
three feet in how many seconds	
Total Phosphorus	
Nitrates	
TSS	

16oz in 1½ min = Flow rate

D.O. 6.08 Salinity .63ppt

%Sat 74.3

TEMP 23.6°C

COND 666us Specific Conductants 683us

PH 7.79 TEMP 22.9°C -63 MV

Tributary 4 Name WallLake West TRIB

Tributary Width in inches	
Tributary Depth in Inches Point 1	
Trilbutary Depth in Inches Point 2	
Tributary Depth in Inches Point 3	
Tributary Depth in Inches Point 4	
Tributary Depth in Inches Point 5	
Tributary Depth in Inches Point 6	
three feet in how many seconds	
Total Phosphorus	
Nitrates	
TSS	

3ft ins 3.5 min 24in covert lots of Organic material

Depths 3in

%SAT 4.3

D.O. .43 Salinity .3ppt

TEMP 23.1°C

COND 553us Specific Conductants 573us

PH 7.21 TEMP 23.3°C -31MV

Page 1

Appendix E
E-coli Sampling Data Sheets

Edglo
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email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0817052275	8/23/05	From:
Date Received	**Sample Matrix**	
8/17/05 1:40:00 PM	Water	To: 8/17/05 11:05:00 AM
Sample ID		
Lake James Chain - Wall West Trib		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ecoli	600-A-85-076	10	480	CFU/100ml	8/17/05 5:00:00 PM	BM

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

Edglo
Laboratories, Inc.

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(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0817052271	8/23/05	**From:**
Date Received	**Sample Matrix**	
8/17/05 1:40:00 PM	Water	**To:** 8/17/05 10:30:00 AM
Sample ID		
Lake James Chain - Wall East Trib		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ecoli	600-A-85-076	1	357	CFU/100ml	8/17/05 5:00:00 PM	BM

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

EDGLO LABORATORIES, INC.

SAMPLE CHAIN OF CUSTODY FORM

CLIENT/COMPANY NAME: AQUATIC ENHANCEMENT

PROJECT/SITE NAME: LAKE JAMES CHAIN DIAGNOSTIC STUDY/WALL LK STUDY

SAMPLER (SIGNATURE): [signature]

REMARKS:

COLLECTION TIME	COLLECTION DATE	SAMPLE LOCATION DESCRIPTION	SAMPLE PRESERVATION	Sample Type GRB.	Sample Type CMP	Sample Type Matrix	Edglo LIMS Laboratory No.	ANALYTICAL TESTS REQUESTED: E-COLI	T. PHOS.	T.S.S.
10:30am	8/17	Wall East Trib		X				X		
7:45am	8/17	Croxton		X				X		
9:13am	8/17	Crooked Creek		X				X		
9:50am	8/17	Follet Creek Baseline		X				X		
11:05am	8/17	Wall West Trib		X				X		
9:30am	8/17	Big Otter Trib		X				X		
9:50am	8/17	Follet Creek Baseline	UNP	X				SEE BELOW*		
10:45am	8/17	Wall Lake East Trib	UNP	X				SEE BELOW*		
11:05	8/17	Wall Lake West Trib	UNP	X				SEE BELOW*		
9:20am	8/17	N Snow Bay	UNP	X					X	X
7:45am	8/17	Croxton Baseline	UNP	X				SEE BELOW*		
8:20am	8/17	Sowles Bay Trib	UNP	X					X	X
9:15	8/17	Wisper Bay Trib	UNP	X					X	X
9:13 ~~[illegible]~~	8/17	Crooked Creek	UNP	X				SEE BELOW*		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)

Temperature Preservation:

Suggested Range: 4 +- 3C

Internal Temp @ Receipt:

[deg C]

PRESERVATIVE CODES

- UNP = Unpreserved
- HNO3 = Nitric Acid, pH < 2 s.u.
- H2SO4 = Sulfuric Acid, pH < 2 s.u.
- HNO3 = Nitric Acid, pH < 2 s.u.
- NaOH = Sodium Hydroxide, pH > 10 s.u.
- HCl = Hydrochloric Acid, pH < 2 s.u.
- ZnOAc = Zinc Acetate (w/NaOH)
- NaT = Sodium Thiosulfate

Headspace in VOA Vials? Y N

Sample Seal Intact (If App)? Y N

MATRIX: W = Water S = Solids/Semi-Solids

Sampling Notes - Special Laboratory Instructions:

ON T-PHOS. & ORTHO PHOS. - PLEASE CONCENTRATE FOR -.007 PPM DETECTION LIMIT

* SEE ACCOMPANYING CHAIN OF CUSTODY INSTRUCTIONS

*SEE ALSO DETECT LIMITS REQUIRED (ATTACHED)

2121 EAST WASHINGTON BOULEVARD FORT WAYNE, INDIANA 46803 PHONE: 260-424-1622 800-891-8442 FAX: 260-424-9124 WWW.EDGLO.COM

Appendix F
Tributary Storm Sampling Laboratory Report Forms

Edglo

Laboratories, Inc.

www.edglo.com
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(219) 424-1622   (800) 891-8442   Fax: (219) 424-9124
email: pknott@edglo.com

Your Environmental Specialists Since 1969

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola   IN   46703

Laboratory #	Report Date	Date/Time Sampled
0719052077	8/ 3/2005	**From:**
Date Received	**Sample Matrix**	
7/18/2005 2:45:00 PM	Water	**To:** 7/16/2005 7:36:00 AM
Sample ID		
Wall - East Trib. Rain		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01	0.14	mg/L	7/29/2005 9:00:00 AM	BK
Nitrate + Nitrite	EPA 300.0	0.01	0.48	mg/L	7/18/2005 12:42:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	0.242	mg/L	8/1/2005 12:30:00 PM	BK
Specific Conductivity	EPA 120.1	1	166	µS/cm@25C	7/20/2005 4:15:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08	0.96	mg/L	7/27/2005 7:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007	0.471	mg/L	8/1/2005 12:30:00 PM	BK
Turbidity	EPA 180.1	0.5	26.3	NTU	8/2/2005 11:00:00 AM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

Edglo

Laboratories, Inc.

Your Environmental Specialists Since 1969

www.edglo.com
2121 E Washington Blvd. Fort Wayne, IN 46803
(219) 424-1622 (800) 891-8442 Fax: (219) 424-9124
email: pknott@edglo.com

Mr. Scott Banfield
Aquatic Enhancement
P.O. Box 1036

Angola IN 46703

Laboratory #	Report Date	Date/Time Sampled
0719052078	8/ 3/2005	From:
Date Received	**Sample Matrix**	
7/18/2005 2:45:00 PM	Water	To: 7/16/2005 7:41:00 AM
Sample ID		
Wall - West Trib. Rain		

Report of Analysis

Parameter	Method Code	MDL	Result	Units	Date/Time	Analyst
Ammonia	EPA 350.3	0.01	0.19	mg/L	7/29/2005 9:00:00 AM	BK
Nitrate + Nitrite	EPA 300.0	0.01	0.26	mg/L	7/18/2005 12:42:00 PM	BM
Ortho Phosphorus	EPA 365.1	0.007	0.142	mg/L	8/1/2005 12:30:00 PM	BK
Specific Conductivity	EPA 120.1	1	308	µS/cm@25C	7/20/2005 4:15:00 PM	DDE
Total Kjeldahl Nitrogen	EPA 351.3	0.08	1.60	mg/L	7/27/2005 7:00:00 AM	LER
Total Phosphorus	EPA 365.1	0.007	0.287	mg/L	8/1/2005 12:30:00 PM	BK
Turbidity	EPA 180.1	0.5	19.1	NTU	8/2/2005 11:00:00 AM	PK

< is less than reported detection limit
Certification Number: INC0203
Page 1

Respectfully Submitted by:

Ed Guindon, President

EDGLO LABORATORIES, INC.

SAMPLE CHAIN OF CUSTODY FORM

CLIENT/COMPANY NAME: AQUATIC ENHANCEMENT

PROJECT/SITE NAME: WALL LAKE ~~/CONCORDE CREEK~~

SAMPLER (SIGNATURE):

REMARKS:

ANALYTICAL TESTS REQUESTED: NITRATE + NITRITE; TKN; AMMONIA NITROGEN; T. PHOS.; ORTHO PHOS.; ~~DISSOLVED PHOS.~~; TURBIDITY; CONDUCTIVITY; DISCHARGE

COLLECTION TIME	COLLECTION DATE	SAMPLE LOCATION DESCRIPTION	SAMPLE PRESERVATION	GRB.	CMP	Matrix	Edglo LIMS Laboratory No.
7:36	7/16/05	WALL EAST TRIB. RAIN	UNP	X			0718052077
7:41	7/16/05	WALL WEST TRIB. RAIN	UNP	X			0718052078
7:41	"	WALL EAST TRIB. RAIN	H_2SO_4	X			
7:35	"	WALL WEST TRIB. RAIN	H_2SO_4	X			

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
	7/18/05	1235	X
X	7/18/05	2:45	Donald D [illegible] II

Temperature Preservation:
Suggested Range: 4 +- 3C
Internal Temp @ Receipt:
[deg C]

PRESERVATIVE CODES

UNP = Unpreserved
HNO3 = Nitric Acid, pH < 2 s.u.
H2SO4 = Sulfuric Acid, pH < 2 s.u.
HNO3 = Nitric Acid, pH < 2 s.u.
NaOH = Sodium Hydroxide, pH > 10 s.u.
HCl = Hydrochloric Acid, pH < 2 s.u.
ZnOAc = Zinc Acetate (w/NaOH)
NaT = Sodium Thiosulfate
Headspace in VOA Vials? Y N
Sample Seal Intact (If App)? Y N
MATRIX: W = Water S = Solids/Semi-Solids

Sampling Notes - Special Laboratory Instructions: QUESTIONS? CALL CELL 260-668-5062

*PLEASE CONCENTRATE SAMPLE FOR .007 PPM PHOS. DETECTION LIMIT (& ORTHO)

I NEED ALL PARAMETERS LISTED RUN FOR EACH OF THESE (2) LOCATIONS. PLEASE SELECT FROM APPROPRIATE PRESERVATION.

*DO NOT RUN ALL PARAMETERS FOR ALL 4 CONTAINERS

2121 EAST WASHINGTON BOULEVARD FORT WAYNE, INDIANA 46803 PHONE: 219-424-1622 800-891-8442 FAX: 219-424-9124 WWW.EDGLO.COM

Appendix G
Boat Launch Survey Form

Date	Day of week	Lake
8/26	Fri	Wall Lake

Public launch Survey Data Sheet

Time launched	Time landed	Type of boat	Type of use
9:30	11:00	Fish	Fish
9:30	11:30	Fish	Fish
9:45	12:30	Fish	Fish
11:10	4:00	Fish	Fish
1:30	~~5~~ 5:00	Fish	Fish
4:00	?	Fish	Fish

use types (mark all that apply)

- fish
- ski
- swim
- cruise high spd
- cruise low spd
- other (describe)

Appendix H
Boating Use Survey Forms

Boat types

pwc	personal watercraft, jet ski, seadoo etc.
fishing	bass boats, row boats etc.
I/O runabout	inboard/outboard, outboard speed boats, inboard ski boats
sailboat	
pontoon	
kayak/canoe	
pedal boat	
Use types	
High speed	5 mph and above and/or producing significant wake
Low speed	trolling or cruising below 5 mph and/or producing little wake
anchored/still	at anchor or drifting, fishing with electric trolling motor in use
sailing	
ski	includes, tubing, skiing, wakeboarding, etc.

Boating Survey Data Sheet

Date	Day of week	Lake
8-12-05	FRI	Wall Lake

Time	Type of boat	Type of use
9:00 a.m.	Pontoon	high Speed
	Fishing	Low Speed
	fishing	anchored

Date	Day of week	Lake
8-12	FRi	Wall Lake

Boating Survey Data Sheet

Time	Type of boat	Type of use
10:00 a.m.	PONTOON	Anchored
	PONTOON	ANchord
	Fishing	Anchord

Boating Survey Data Sheet

Date	Day of week	Lake
8-12	Fri	Wall Lake

Time	Type of boat	Type of use
11:00 a.m.	Pontoon	Low Speed
	Pontoon	Anchord
	Fishing	Low speed

Boating Survey Data Sheet

Date	Day of week	Lake
8-12	FRI	Wall Lake

Time	Type of boat	Type of use
12:00 p.m.	PONTOON	Low speed
	PONTOON	STILL
	PONTOON	STILL
	PedAL BOAT	Low speed

Date	Day of week	Lake
8-12	FRI	Wall Lake

Boating Survey Data Sheet

Time	Type of boat	Type of use
1:00 p.m.	PONTOON	ANchord
	FIShiNg	Anchord
	PedAL BOAT	Low Speed

Boating Survey Data Sheet

Date	Day of week	Lake
8-12	FRI	Wall Lake

Time	Type of boat	Type of use
2:00 p.m.	Fishing	drifting

Boating Survey Data Sheet

Date	Day of week	Lake
8-12		Wall Lake

Time	Type of boat	Type of use
3:00 p.m.	Pontoon	Anchord

Boating Survey Data Sheet

Date	Day of week	Lake
8-12		Wall Lake

Time	Type of boat	Type of use
4:00 p.m.	Pontoon	Anchored
	Fishing	Low speed

Boating Survey Data Sheet

Date	Day of week	Lake
8-12		Wall Lake

Time	Type of boat	Type of use
5:00 p.m.	PonToon	Anchord
	PonToon	Low Speed
	Fishing	Anchored

Date	Day of week	Lake
Aug 27	SAT	Wall Lake

Boating Survey Data Sheet

Time	Type of boat	Type of use
9:00 a.m.	Pontoon	Anchored
	Pontoon	Anchored
	Pontoon	Slow Speed

Boating Survey Data Sheet

Date	Day of week	Lake
8-27	SAT	Wall Lake

Time

10:00 a.m.

Type of boat	Type of use
PONTOON	LOW SPEED
PEDALBOAT	

Date	Day of week	Lake
8-27	SAT	Wall Lake

Boating Survey Data Sheet

Time	Type of boat	Type of use
11:00 a.m.	Pontoon	Anchored
	Pontoon	Low speed
	Fishing	drifting
	Fishing	Low speed

Boating Survey Data Sheet

Date	Day of week	Lake
8-27	Sat	Wall Lake

Time	Type of boat	Type of use
12:00 p.m.	Sail Boat	
	Fishing	anchored
	Pedal Boat	
	Pontoon	Anchored

Boating Survey Data Sheet

Date	Day of week	Lake
8-27	Sat	Wall Lake

Time	Type of boat	Type of use
1:00 p.m.	Pontoon	high speed
	Fishing	Drifting
	Fishing	Anchored
	Fishing	anchored
	Sailboat	

Boating Survey Data Sheet

Date	Day of week	Lake
8-27	Sat	Wall Lake

Time	Type of boat	Type of use
2:00 p.m.	Pontoon	Low Speed
	Pontoon	Low Speed
	Fishing	Anchored
	Fishing	Low Speed
	Fishing	Low Speed
	Pedal Boat	

Date	Day of week	Lake	Boating Survey Data Sheet
8-27	Sat	Wall Lake	

Time	Type of boat	Type of use
3:00 p.m.	Fishing	Anchored
	Fishing	Anchored
	Fishing	Anchored
	Pontoon	Anchored
	Pontoon	Anchored
	Pontoon	Slow speed
	Sail boat	
	Pedal Boat	

Date	Day of week	Lake	Boating Survey Data Sheet
5-27	Sat	Wall Lake	

Time	Type of boat	Type of use	
4:00 p.m.	Fishing	high Speed	
	Fishing	high Speed	
	Fishing	Anchored	
	Fishing	Anchored	
	Sail boat		
	Pontoon	Anchored	
	Pontoon	Anchored	
	Pontoon	high Speed	-Ski - Tube
	Pontoon	Low Speed	

Date	Day of week	Lake
8-27	Sat	Wall Lake

Boating Survey Data Sheet

Time	Type of boat	Type of use
5:00 p.m.	Pontoon	Low Speed
	Pontoon	Low speed
	Pontoon	Lowspeed
	Pontoon	high Speed — Ski-Tube
	Fishing	Anchored
	Fishing	Low Speed
	Fishing	Lowspeed
	Fishing	Anchored
	Canoe	